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WATER QUALITY PROTECTION

HEARING

BEFORE THE

SUBCOMMITTEE ON
CONSERVATION AND FORESTRY

OF THE

COMMITTEE ON AGRICULTURE,
NUTRITION, AND FORESTRY
UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

ON

WATER QUALITY PROTECTION

OCTOBER 24, 1989

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WATER QUALITY PROTECTION

TUESDAY, OCTOBER 24, 1989

U.S. SENATE,
SUBCOMMITTEE ON CONSERVATION AND FORESTRY OF THE
COMMITTEE ON AGRICULTURE, NUTRITION, AND FORESTRY,
Washington, DC.

The subcommittee met, pursuant to notice, at 9 a.m., in room SR-332, Russell Senate Office Building, Hon. Wyche Fowler, Jr. (chairman of the subcommittee) presiding.

Present or submitting a statement: Senators Fowler, Baucus, Kerrey, Bond, and Gorton.

STATEMENT OF HON. WYCHE FOWLER, JR., A U.S. SENATOR FROM GEORGIA

Senator FOWLER. Good morning, everybody, and welcome to the Subcommittee on Conservation and Forestry of the Agriculture Committee to our hearing on water quality protection.

Water contamination presents potentially the greatest problem of American agriculture, and one of the most dangerous to ignore. We know that agricultural runoff is the greatest nonpoint source of surface water pollution in the country, accounting for fully half of all water pollution.

Farm runoff accounts for 50 percent of sedimentation in surface water and up to 70 percent of the excess nutrients, both of which reduce light penetration, deplete oxygen and damage vegetation and aquatic life. Ground water contamination by agricultural chemicals suspected of causing cancer has been reported in 41 States. A yet to be completed EPA study confirms contamination by 46 chemicals, many of them suspected carcinogens in 26 States.

Aldicarb, the most acutely toxic pesticide registered by the EPA, has been found in the water of 16 States. Several of the other chemicals that have been most commonly detected are listed as probable carcinogens. The U.S. Department of Agriculture calculates that 46 percent of U.S. counties contain ground water susceptible to contamination from pesticides and fertilizers.

Conventional treatment does not remove many of these chemicals from our drinking water. Pesticides continue to be detected in fish, shellfish, and bird life. This may sound like a lot of very disturbing information, but in fact, we know very little about the extent of the hazards of water contamination. This, it seems to me, is what is truly disturbing. We have no comprehensive or systematic testing of our wells and watersheds. Research simply is not keeping up with the problem. There are a number of reasons for this from funding shortages to the narrow isolated specialization of many of our scientific studies.

We have significant problems even compiling and comparing information that is available. For example, the States all compile information on fertilizer use. Every dealer is required to report sales of restricted chemicals. Yet we have no national statistics for any of this when all we have to do, should have to do, is a way to add up the figures. It should come as no surprise then that farmers have poor information on the consequences of the practices they employ beyond this year's yield.

The U.S. Extension Service, who our farmers rely on for so much of their information, has not taken adequate steps to educate the farmers about the possible consequences of polluting our water supplies with overuse of pesticides and fertilizers. The recent National Research Council's study of alternative farming methods concluded that Extension is providing very little guidance in this important area. Some of the States are way ahead of us in water quality education and protection.

I am very interested to hear from some of our panelists today including my colleague Senator Kohl, who will be here momentarily, about what the Federal Government can learn from the States. Simply put, we have to improve our efforts. We have to get better data. It is not that we do not have any research going on, but it has not been directed with a proper emphasis on these important questions of water quality.

If we are going to fund the research, we are also going to have to insist that it address these priority questions, namely, testing our water and reporting the findings. Finally, as the information comes in, we are going to have to consider tighter regulation to protect water resources. After all, Federal agricultural policies from water quality standards to pesticide regulations drive many of the damaging practices of high input farming, and are not balanced by considerations of the potential public health problems they may cause.

Existing pesticide regulations keep many older products, known to pose health and environmental hazards, in use even though they could not be registered as a new pesticide under today's standards.

The NRC study found that fertilizers and pesticides are often applied at rates which cannot be economically justified without including farm payment programs. We simply cannot continue to encourage farmers to maximize program benefits at the expense of the environment and public health. We have to reduce the water contamination costs, which amount to billions of dollars per year, incurred by current production methods, and we have to incorporate these real costs into the system.

Perhaps we are going to have to bring the strategy we are applying more and more to corporations, bring that strategy also to the farm, and say if you pollute, you pay. I am not very happy adopting what I am sure some will consider to be a punitive tone because I know that farmers themselves have the greatest interest in protecting the water that their families drink and that is essential to their operation.

But the days of ignoring the impact of farm operations on our water supply has to be tackled. The trend toward greater and greater contamination must be reversed. We have to help farmers meet that responsibility and make sure that none get by with simply ignoring it. Even without complete information, we can already draw one clear conclusion: that it will be much easier to address problems of water contamination by preventative measures in the field. Implementing conservation tillage, integrated pest management, low-input crop rotations, will be a snap compared to clean up of estuaries and aquifers.

At the very least, we should not penalize farmers as we do in existing programs for taking steps toward good stewardship of their water resources. Right now, it seems to me, we cannot afford to pretend, that since we remain ignorant and the problem is invisible, that we have nothing to worry about.

Such denial and shortsightedness will have very real consequences. So, today, I hope we can begin the process as we move toward the 1990 farm bill of directly confronting the issue of water purity and what we can and need to do about it.

Our first witness is the Senator from Wisconsin, our new Senator and my colleague, Senator Herb Kohl. Welcome, Senator Kohl.

STATEMENT OF HON. HERBERT H. KOHL, A U.S. SENATOR FROM WISCONSIN

Senator KOHL. Mr. Chairman, I appreciate very much this opportunity to address you and your committee this morning. I would like to begin by commending you, Senator Fowler, for the work you have already done on this issue, and for your plans to make water quality a priority for the 1990 farm bill.

I would like to also thank you for allowing a fellow Wisconsinite to be heard this morning. Kevin Kessler is here to offer the Wisconsin Department of Natural Resources and the Wisconsin Department of Agriculture's thoughts on water quality and agricultural programs.

The fact that Mr. Kessler is here representing both agencies demonstrates the strength of the State's work in this area. Wisconsin is a role model among States in its ground and surface water protection efforts, due in no small part to the cooperation between these two agencies.

The State's work in this area is what brings me here today. Both to offer it as an example for other States to follow—or to be asked to follow—in dealing with agricultural chemical use, and to caution that Federal water quality efforts be fashioned in such a way as to strengthen—not impede—existing State programs.

Wisconsin's ground water program is multidisciplinary and multiagency. It includes:

—health-based regulatory standards set by the Department of Natural Resources;

—a well sampling and ground water monitoring program conducted jointly by the Department of Natural Resources and the Department of Agriculture;

—the promotion of on-farm best management practices developed by the Department of Agriculture and the Cooperative Extension Service; and

—a State-sponsored sustainable agriculture research and education program.

By no means is it completely successful yet. But its strength lies in offering the agricultural community the information it needs to reduce its chemical use, while assuring those dependent on ground water of their drinking water's safety.

I believe that, as a simple matter of public health and safety, States with no similar commitment to ground water protection should be required to adopt one.

I also feel very strongly that the U.S. Department of Agriculture should play a greater role in moving the agricultural community toward reducing its onfarm chemical use. Giving farmers greater planning flexibility through commodity programs is one way to do that. USDA should also be required to expand its commitment to sustainable agricultural research and education.

Yet I am nervous about giving USDA free rein in the areas of well testing and the development of onfarm pesticide use plans. Many States have well survey programs in place, and adding a Federal program in this area may confuse the lines of authority.

USDA also has little knowledge about local soil and water conditions. Any development of farm-specific chemical management plans must be done in a way that allows States a cooperating and coordinating role in their development and implementation.

For a moment let me go back to a point I just made.

Expanding USDA's sustainable agriculture research and education efforts should be a cornerstone of any Federal water quality initiative. Preventing further ground water contamination from farm chemicals is the most cost-effective means we have of dealing with water quality problems.

For this reason, I was very disappointed with this year's water quality initiative offered by the Department. Not only did it fail to fund the one successful program in this area—the LISA Program—but the research suggested was duplicative and unfocused.

The 1990 farm bill must include a research and education title that gives USDA a greater role and a clearer mandate in this area. The LISA Program should be expanded to provide both better coordination within and between Federal agencies in water quality work, and greater participation in education by States, farmers, and private organizations that have expertise in this area. In addition, there should be a method for making USDA more accountable for its work in sustainable agriculture.

Mr. Chairman, it has been a pleasure to be here today. I also want to thank you again for giving me the opportunity to offer my thoughts here this morning. I would like also to offer my help in any way that I can in focusing Federal attention on water quality programs in the 1990 farm bill. I appreciate your having me here.

Senator FOWLER. Herb, thank you very much for very specific and thoughtful suggestions coming out of your State's experience in Wisconsin. I do look forward to working with you, and thank you very much for taking the time to come over this morning.

The prepared statement of Senator Bond will be inserted in the record at this point.

[The prepared statement of Senator Bond follows:]

PREPARED STATEMENT OF HON. CHRISTOPHER S. "KIT" BOND, A U.S. SENATOR FROM MISSOURI

Mr. Chairman, it is a pleasure to join you this morning as we continue our investigation regarding the current status, as well as the future outlook of our Nation's ground water quality. This subcommittee, along with several others in Congress, recognizes the long-term importance of protecting this vital resource and I commend you for your ongoing interest in this area.

Although previous hearings have established the importance of preserving water quality, there remains uncertainties regarding both current quality levels and the optimal methods to address problem areas. Perhaps the sole point of agreement is that prevention is preferred to prescription.

Just as it does with soil conservation, agriculture has a tremendous stake in preserving water quality. I am unaware of any farmer who has purposely contaminated his water supply—a supply that his own family often relies upon. It is doubtful that even producers with large irrigated farms would knowingly contaminate their water supply. A recent National Research Council report estimated that 70 percent of the water withdrawn from aquifers is used for irrigation.

The NRC report recommends that $500 million in new monies be devoted to agricultural research. The study found that "Water can be used more efficiently in agriculture, and agriculture's adverse effects on water quality could be lessened if soil-plant-air-water interactions were better understood. A systems approach could be used to consider the cost and availability of water, irrigation methods, drainage requirements, crop fertility and pest control needs, the timing of field and harvest operations, and methods to protect water quality."

It is also important to understand the relationships between water quality and both commodity and conservation programs. I believe that Congress and the administration understand this and will incorporate coordinated programs into the next farm bill. It is for this reason that the conservation title of the farm bill should be developed in tandem with the commodity title.

Water quality will always be important—the challenge is to better understand techniques which prevent contamination. The recent NRC reports have shed a great deal of light on this and certainly warrant thoughtful consideration.

Senator **FOWLER**. Our first panel is Dr. Charles Benbrook, the executive director of the Board on Agriculture, National Research Council, and Dr. Terry Nipp, director of the Water Quality Initiative. Gentlemen, come on up here. I am feeling desperately lonesome. Well, not that close. We might have another Senator or two come in. Those two will be fine. Appreciate very much your participation and timeliness. Dr. Benbrook, would you like to begin?

STATEMENT OF CHARLES M. BENBROOK, EXECUTIVE DIRECTOR, BOARD ON AGRICULTURE, NATIONAL RESEARCH COUNCIL, WASHINGTON, DC

Dr. **BENBROOK**. Yes, Mr. Chairman, I would be delighted to. First of all, I would like to commend you for your leadership in developing and introducing the only really significant legislative proposals in the area of sustainable agriculture. As you know, Mr. Chairman, you have raised the blood pressure of a lot of American agriculture, but you are also making people think. And occasionally that can be useful in helping identify some areas for change.

I have submitted a prepared statement for the record and would like to highlight a few points that I would direct your attention to as you think about the needs in the next farm bill.

WE MUST ACCEPT THE NEED FOR SOME CHANGE AND SOME ACTION

First of all, I think that the time has arrived when we know enough about agricultural water quality problems that we must accept the need for some change and some action, both to take remedial steps in areas where water quality problems have already been documented and understood and have reached a level where society is no longer willing to accept the level of degradation that exists.

I think we also know enough now to hopefully recognize the wisdom in a policy of prevention to avoid the emergence of new, even more serious problems in certain areas. So I think that the time has come for more than just research.

ADVANCE WATER QUALITY PROTECTION THROUGH THE COMMODITY PROGRAM TITLES

I hope that the next farm bill will include a number of provisions that will be helpful. Within the farm bill, I think the major areas that require thoughtful attention in providing farmers some new economic opportunities to change their management systems in ways that will advance water quality protection are the commodity program titles, the conservation title, the very important reform of both the disaster programs and crop insurance provisions, the research and extension titles that will be a major focus, and possibly even some regulatory provisions that may be included in the farm bill if Congress is not successful in passing pesticide regulatory legislation in the current session.

SOME OF THE MAJOR AREAS FOR CHANGE THAT COULD BE CONSTRUCTIVE

Let me just point out some of the major areas for change that could be constructive.

OUR REPORT MAKES A STRONG CALL FOR INCREASED FLEXIBILITY

Within the commodity program titles, our report makes a strong call for increased flexibility. The reason that farmers need increased flexibility in order to use their base acres in crop rotations is that at the present time farmers are locked into cropping patterns that are not only creating agronomic problems for them and hurting their profitability, but also creating environmental problems, and in many areas water quality problems.

It is not that farmers are not eager to change their management systems, but that they are simply locked out of the opportunity to do so by the current rules of the programs. Right now Government program payments constitute anywhere from 15 to 20 percent, even up to 40 percent of the income that farmers receive from their crops, and so they really have to pay attention to what the commodity programs tell them to do.

There are not too many farmers who are able to just go out of the farm programs and do what they think is best for their soils and the environment. So, building flexibility into the commodity programs is certainly going to be a key.

LAND IN THE CRP

Another very important issue that will be before the Congress is what to do with the next 15 million acres or so of land that hopefully will be enrolled in the Conservation Reserve Program. In your home State, as you know, there has been great success with the planting of trees on CRP land, so that this particular program has been a major benefit both for the control of erosion but also in revitalizing some of your rural counties. Well, in other parts of the country, the CRP has not really been that much of a significant factor, yet because enrollment rates are very low, particularly in much of the Midwest and the Eastern part of the country, where you have fairly productive row cropland, high rates of sheet and rill erosion, and some very serious water quality programs.

And many people are assessing the opportunities to build some water quality provisions into the CRP and to target the CRP enrollment for the benefit of water quality. I think that that is going to be an issue of considerable importance because some people believe we should not fill the CRP up to 45 million acres because stocks are getting tight, and there are some real questions about what directions we should go in. In Maryland farmers that enroll land in the CRP are receiving a $20 additional payment from the State because of the State's perception of water quality benefits, and I think that is going to be a State level policy innovation that is looked at around the country.

Senator **Fowler**. Is that the stated reason that Maryland has added that $20 add-on? Water quality?

Dr. **Benbrook**. It is part of the Chesapeake Bay Protection Program, and similar provisions are before the legislature in Pennsylvania and in Virginia.

DISASTER PROGRAMS AND CROP INSURANCE

The Secretary of Agriculture has pledged to work with the Congress in bringing about a fundamental reform in both our disaster programs and crop insurance. His stated goal is to either go with a crop insurance program or a disaster program but not with both. It is very important for the Congress to assess both the types of risks that will be covered by such a program as well as the basis for participation because the kinds of natural events, climatic events, that bring about a need for either disaster payments or crop insurance payments are droughts and floods.

Droughts and floods also tend to be associated with serious environmental problems. When we have droughts, we have wind erosion. We have a build up of chemicals in the soil which tend to run off the next year. When we have floods, we have too much water going through an agricultural system and it picks up a lot of nutrients. So there are good physical and biological reasons to look at the environmental provisions that are built into any reform of the disaster and crop insurance programs.

THE NEED FOR RECORDKEEPING

A last point I would like to discuss is that in a number of titles, and in FIFRA legislation that is under review in the House, the need for recordkeeping comes up over and over again as one of the new directions that we might move in. We need better records on pesticide use and fertilizer use, as you noted, Mr. Chairman, in order to improve our ability to monitor and target where the problems are.

And I would just alert the Congress in thinking about recordkeeping provisions, to pay attention to the opportunity to compile records in a cost-effective manner. Records are very costly to compile, to transfer, to analyze, and they can be a great drain on the system without really providing much useful information. So I think in any recordkeeping provisions that are developed, it is important to target the recordkeeping to areas where there is a known problem, to restrict the data elements, if you will, that are compiled to those which really make a difference, and to assure that there are no more monitoring records developed than are needed to get the information required.

For example, a 2 percent sample of the rural wells in most areas would provide a pretty clear picture of the water quality in the area, and one would not have to sample all the wells, and obviously, you know, there is an enormous difference in cost between a 2 percent sample and a 100 percent sample. So I would just alert the Congress that since recordkeeping may be a part of several different titles, some assessment of the most effective and cost efficient way to do that might be a good investment of time. Thank you.

[The prepared statement and attachments of Dr. Benbrook appear at the conclusion of the hearing.]

Senator FOWLER. I think before we go to our questions, Dr. Nipp, we will have your presentation. This is Dr. Terry Nipp, the director of the Water Quality Initiative at the National Association of State Universities and Land-Grant Colleges. Welcome, Dr. Nipp.

STATEMENT OF TERRY L. NIPP, DIRECTOR, WATER QUALITY INITIATIVE, NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND-GRANT COLLEGES (NASULGC), WASHINGTON, DC

Dr. NIPP. Mr. Chairman, I appreciate the opportunity to speak before you. I have submitted prepared testimony for the record, and I will try to summarize here.

Senator FOWLER. Thank you.

ESCOP AND ECOP

Dr. NIPP. The National Association of State Universities and Land-Grant Colleges comprises a broad array of universities and includes all of the land-grant universities. Within that structure, there are two committees that are, I think, of particular relevance to the concerns before us here today, the Experiment Station Committee on Organization and Policy (ESCOP) and the Extension Committee on Organization and Policy (ECOP).

Both of these groups from the land-grant systems have been concerned about water quality and its relationship to agricultural production for a number of years.

1985 REPORT

A report came out in 1985 entitled "Ground Water Quality and Management: Research and Extension," which provides a litany of research and education needs that are going to have to be addressed at some point as we wrestle to come to grips with the question of water quality contamination. I quote from that particular report. Again, this is from 1985:

> Few doubt that contamination of ground water is a growing problem. The impact of agriculture on water quality and quantity is an issue of major national impor-

> tance. Proper management of agricultural systems to maintain acceptable ground water quality is increasing in importance. Research efforts need to be focused on physical, chemical and biological processes that influence ground water quality. * * * There is an immediate need for increased research on source on prevention, fate, remedial, impact and institutional issues.

This report also addressed the needs of the extension and the education committees and pointed out the severe shortages of trained and adequately prepared personnel to go forward to present the kinds of information we have available to us.

ADDRESSING NEEDS

In your opening remarks, you identified a number of the research and the education needs that are before us, and we are very supportive of the need to address these concerns.

I should state that as State organizations we are very supportive of the efforts of the Department of Agriculture to begin to address these issues, but as an organization of States, we also have our own agenda and while we are very supportive of the efforts that are underway so far, we would like to see things go much farther. We would like to see a lot more effort involved. We would like to see a much greater increase in support for a national agenda. We would like to see much greater coordination of the programs that are, in fact, in place and underway.

HOW MUCH MONEY ARE THE STATES SPENDING ON WATER QUALITY RESEARCH COMPARED TO THE FEDERAL GOVERNMENT?

A question that I am usually asked is: how much money are the States spending on water quality research compared to the Federal Government? That is not an easy question to answer. A study was done that began to look at how these funds are broken down, and this study involved the use of the Current Research Information System (CRIS), which is a computerized data base that cites all ongoing research.

A search was done of the system which identified all projects going on out in the country that included some component of water quality research. If you have ever talked to anyone who has worked with the system, you will know that that will include studies that are not really relevant to water quality, simply because the word "water" is included somewhere in the course of the project description. So individuals went through and sorted out every project that might be relevant by hand, assigned them to 10 categories, and when it was all said and done and the dust settled, it looks like in 1987 about $16 million was being spent through the USDA Cooperative Research Service, about $85 million is being spent by the States themselves on their own programs. So at this point, the State investment in research is immensely larger than the Federal counterpart.

I can provide a list of research needs that the States feel are a particular concern. I should say that of the new Federal funds that were available in last year's budget over 238 research proposals were submitted by State institutions and research scientists that have projects and programs ready to be implemented. Of those 238 proposals, only 23 were able to be funded because of the limited resources. I am told that of those 238, easily half were of high quality and could have been funded had resources been available.

DATA COLLECTION

On the data collection side, I would like to quote from a report that came out from the National Research Council entitled "Pesticides and Ground Water Quality"—this report came out also several years ago—which states:

> Some 200 pesticides are in common use, and a wide range of hydrogeologic conditions affect the susceptibility of ground waters to contamination. Clearly it is impracticable to sample every aquifer and test for every pesticide. Rather, efficient monitoring of resources depends on the establishment of systematic procedures for sampling and testing and the collection of data that can be used to identify critical site/specific combinations.

This is, in fact, one of our greatest areas of need. We have a huge number of research programs that are underway. EPA is involved. USDA is involved. USGS is involved. A number of State institutions are involved. Unfortunately we do not all use the same sampling protocol. We do not all use the same laboratory techniques. And while there are preliminary efforts to try to define what a standard set of data would consist of and how you would go about collecting that data, we have not reached any form of official consensus, and this will greatly hinder the effectiveness of the work that we are doing simply because a lot of the work is not going to be comparable since we never agreed on what it was we were going to go out and measure in the first place.

EDUCATION

On the education side, last year about $1.5 million in new funding was available through the Department for extension activities. That money was focused to look at the interactions of pesticides, soils and water quality, the interactions of nitrogen fertilizers, soils and water quality and the testing and treatment of rural water supplies. However, if you divide $1.5 million by 50 odd-States and several additional territories, you end up with about $25,000 for a State. Even allowing for the fact that there are matching funds, that gives you about $50,000 in new money per State to develop education programs which is just severely inadequate to address the needs that are before us.

TECHNICAL ASSISTANCE

On the technical assistance side, the Soil Conservation Service, as you know, is the technical assistance arm of the Department of Agriculture and the universities and the State extension service have been working with the Soil Conservation Service to develop water quality components for their technical guides. There are a number of problems in the technical assistance area regarding water quality largely having to do with the fact that we have not acquired a lot of the basic kinds of information that we did have available for developing soil erosion plans.

We do not have the same sophistication in being able to predict the impact of agricultural chemicals and how they are going to move through the environment. Now I should make one thing very,

very clear. There have been suggestions by some people that since we need to go out and do so much research, since we need to go out and collect so much data, we really need to be careful before we go out and develop education programs. We need to be careful before we go out and develop technology assistance programs. I think I can say unequivocally for the extension community and for the technical assistance community, this is simply not the case. There is a tremendous amount that we know how to do today.

There are a tremendous number of practices that we can apply today. We need to get what we have on the shelf off the shelf and out in the field and implemented.

[The prepared statement and attachments of Dr. Nipp appear at the conclusion of the hearing.]

Senator FOWLER. May I interrupt you here, Dr. Nipp?

Dr. NIPP. Yes, sir. Of course.

Senator FOWLER. On that point and one that you raised a little earlier in your remarks, I refrained from including all of our Government witnesses in this initial hearing today from EPA and USDA and USGS and all of them, rightly or wrongly, because I wanted to get a look at what our panelists described our needs in water quality. But since you have raised it from both sides, go ahead and elaborate a minute. In your opinion, are our Government agencies coordinating their efforts at this time, not only their research efforts but also the technology that you describe that is already available and on the shelf? Is that being done in your opinion?

Dr. NIPP. Well, I have been told by a number of people that the coordination that has evolved to address water quality has evoked a greater level of coordination between the agencies than has ever occurred for any issue ever before, and I have been to a number of these kinds of coordination meetings. And it is true that things are better than they have ever been before. That does not mean they are anywhere near good enough. There is a technical integration group which is an ad hoc consortium of scientists from each of the agencies that are meeting on their own, trying to compare notes, look at what each other's programs involve, trying to begin the integration of their respective efforts.

But I think these are very fledgling efforts. Related to your question is: how well is the water quality initiative integrated into the LISA Program and how well is it coordinated with low-input efforts? The answer to that is not very well yet. I think there is a willingness to work. A number of the scientists who will be receiving funding to do low input, I am sure, will be applying for money from the water quality program. At the university level, I think we are very willing to work in both domains. We need to coordinate these programs very much, but with the water quality initiative being still a relatively new effort, I think we have only begun to develop the kinds of coordinating mechanisms that need to be in place.

At the Washington level, the administrative heads of programs all know who each other are. They do meet. They do sit down to discuss how they are going to coordinate their programs. At the university level, the scientists know who their counterparts are, but the actual structuring of comprehensive, integrated programs where the scientists sit down together and are able to commit the financial resources of their respective institutions, we have not got to that point yet.

Senator FOWLER. Thank you.

Dr. Benbrook, I read, of course, your most recent report on alternative agriculture, and found it extremely helpful in targeting our attention in various areas of conservation as we go into the 1990 farm bill. Before we get to water quality, let me ask you one of the key questions, and that is the charges, as you know, against alternative agricultural practices in their most general sense is that always that the yields from the farm that are necessary to feed this country—talking about exports for a minute—the yields necessary to feed our own countrymen simply cannot be maintained under these alternative farming practices. Is this true?

Dr. BENBROOK. No, it is not. In fact, I think that the reason that we were given the opportunity to do this study, and the reason that it has captured so much attention, is a growing recognition among leaders in agriculture today that we cannot continue to provide both the domestic market and our foreign customers with either the quantity or the quality foods that we are doing today under conventional practices. They simply are not sustainable either from the perspective of the environment or in terms of economic performance.

We have managed to stay one step ahead of pests. We have managed to maintain our soil fertility levels. We have moved out on to a lot of fragile soils but certainly do not have many more to move out on to, and all indications are that if we keep producing food and fiber the way we are in this country today that there simply will be a significant collapse in our ability to meet all the needs. And as a result, we have to look for some different ways to go about the business of producing food and fiber.

What we have done in the 1970's and 1980's, Mr. Chairman, is use chemistry and energy in very sophisticated ways to intensify, to expand the production capacity of farming systems, and the two principal problems that arise from this approach are that we are finding it very costly in terms of the environment, and in terms of production costs. As soon as energy prices start to go up, it will get even more costly. The other worrisome factor to remember is that there are a lot of environmental and food safety problems that are going to continue to recur as long as current production systems are so dependent on animal drugs and pesticides.

It is not going to be a problem everywhere. It is not going to be a problem with all crops, but it will be a recurrent problem in many of our most intensive production regions. And as a result, the strategy for the next decade is to try to integrate some biology and some ecology back into production systems so that we get more out of the natural resources that we are utilizing, and really not fight nature quite so much but use it. Farmers that do that effectively now achieve just as high, sometimes even higher crop yields, than those using conventional practices.

Senator FOWLER. On the water, you mentioned in your testimony that certain information is critical in determining water quality. What should our methods be? Is well testing the right way to go? If so, do we test every well? How do we target? How do we track it in your opinion?

Dr. **Benbrook.** Well, there are three major water quality problems: sedimentation, which is eroding soil moving into streams, rivers, reservoirs, estuaries; contamination of water with soil nutrients, principally nitrogen, nitrate contamination; and then pesticides.

Now we have made a lot of progress with the conservation title of the farm bill and the CRP in dealing with sedimentation problems. We have some new filter strip provisions and are beginning to look at some creative ways to manage the interface between cultivated cropland and streams and rivers. So I think we are doing pretty much what can be done in that area.

In the area of nitrates and fertilizers, a statistically designed sampling approach really is what makes sense. We already know, Mr. Chairman, in a lot of major farming areas pretty well what the levels of nitrates are in most of the wells. We know enough to select out those areas that have a pretty severe problem, and we really do not need to know with any more precision what the levels are to make a judgment that it is time to take some actions to improve the efficiency of nutrient use in those areas.

In the case of pesticides, we are more dependent, I think, on developing better and more information because the circumstances that give rise to pesticide contamination in ground water are more complex and tend to be more localized. The problem with pesticides in ground water tends to be restricted to relatively few chemicals and tends to occur in regions that have some combination of soil characteristics, hydrogeological features or cropping practices that give rise to a more rapid movement of the applied pesticides down through the soil horizon.

But we have a pretty good idea of where some of the real problem areas are. In Senator Kohl's State of Wisconsin, for example, it is well-known that the central sands region where the soils tend to be sandy, and are irrigated and are now used for producing pretty intensive vegetable cropping systems, we know a fair amount about the water quality problems there, and that is where the State is focusing much of its effort as you will hear from Kevin Kessler later.

So many of the real major problem areas are already well-known and fairly well documented. The problem, though, is trying to create an economic climate in which farmers will, in fact, adopt proven alternatives. As Terry has pointed out——

Senator **Fowler.** How do we—that gets back to the research and the public and private efforts. How do we encourage, for lack of a better verb, the scientific community to spend a little of their research, more of their research time, on educating and encouraging the farmer that these things are possible?

Dr. **Benbrook.** Well, I think that the scientific community has been putting a lot more effort into it, and as Terry said, there were several hundred excellent proposals that came forth when a small amount of money was made available in this last budget. And you are aware of our major research initiative where we have proposed a large increase in the competitive grants program, with a major portion of that money devoted to work in natural resources and environment.

There is absolutely no doubt in anyone's mind that the scientists out there in the community want to work on these problems. They understand that these are amongst the most serious problems confronting not just the farming community, but our rural communities and the country as a whole. So there is an eagerness to get on with the work. But the problem is that the scientists are coming to realize that despite their best efforts, carefully documented research that shows exactly what the problem is, what has brought it about, and how to solve it, and even after transferring that information to the farmer, the farmer still says "but I can make more money keeping doing what I am doing." And that is the problem.

The problem is that the economic incentives under our current programs still are such that it pays to pollute the environment. And, you know, farmers are private businessmen. They have not had an easy decade. And it is simply not going to be enough to give them information about some opportunities that they have to do a better job with the environment. It has to pay for them and right now the perception amongst farmers is that they really cannot improve their profitability any by doing a better job managing nitrogen, by cutting back on their herbicides and going to cultivation. They really feel that they are doing the best job they can with what labor they have, the capital, and land.

And in many respects, Mr. Chairman, I think that they are probably right.

Senator FOWLER. Senator Bond.

Senator BOND. Thank you, Mr. Chairman. I am very much interested in the testimony of these two witnesses today. I apologize I was not here at the beginning. I do have a prepared statement that I would like to hand in.

And I will say that we certainly all agree that prevention is the best way to go when you are talking about dealing with water quality impairment. Mr. Benbrook, we have experienced in Missouri many things in which you have spoken about. Back in the early 1980's we identified soil loss, soil erosion, as one of our major problems. We had the distinction of ranking No. 2 or 3 in the Nation, and started to work on conservation programs even before the CRP. We have made some progress there, but you commended the chairman that his State has had great success in planting trees, getting trees planted on CRP. We have had an abysmal record in Missouri, less than 1 percent. Any thoughts on how we might get more trees planted on CRP in the Midwest?

[The prepared statement of Senator Bond can be found on page 5.]

Dr. BENBROOK. Well, I think that again it goes back to economics. The opportunity to plant CRP ground in pine trees, given the fact that there is a viable and strong commercial forestry industry in Georgia, a market for the trees, and that is really why it happened. In Missouri, if that market opportunity is not there, then it would probably be more difficult and quite costly. In a State like Missouri where you have fairly productive soils and a pretty diversified agricultural base, the opportunity to use CRP ground for productive purposes might be more in the area of growing forages or hay for livestock.

There are many people that are going to be advocating in the 1990 farm bill a reassessment of the prohibition against haying and grazing on CRP land. Right now most of your ground in your State rents probably for $90 to $110 an acre, the better land, and if the CRP rental rates are only $70 or $80.

Senator **Bond**. $65.

Dr. **Benbrook**. $65.

Senator **Bond**. $60, $65.

Dr. **Benbrook**. It is just not profitable for a farmer to put his ground into CRP. He cannot even cover his rent, let alone the cost of controlling weeds, and it is not likely in my judgment that the Federal Government will be able to afford increasing the rental rates enough to make up that difference. So there has to be some change in CRP policy if there is going to be an increase in the enrollment in States like Missouri, in southern Illinois, in Tennessee, in Vermont and in other States that have some pretty serious erosion problems but have almost no ground in the CRP.

There is really two ways that it can happen. One is that the States or perhaps the Federal Government could add an additional payment for water quality benefits achieved from the enrollment of land into the CRP. And the other is to allow farmers to retain the right to plant CRP land in forages and harvest it. In a State like Missouri where you have a pretty decent pattern of rainfall, the ability to graze that land could result in a $30 or $40 net return to the farmer. That added to his CRP payment would begin to make participation look pretty attractive.

Senator **Bond**. It also might get some of our cattle producers a little bit upset because we are the leading hay producing State. There is always concern that we are going to put more pressure on the cattle market by turning this over to grazing. We have, as you may know, our conservation department, which has a unique eighth-of-a-cent sales tax, does provide cost share in certain circumstances, apportion cost share for planting in warm season legumes and other wildlife cover which is very important.

One of the ideas that came to our attention recently, and there is an article on it here in the Soybean Digest, is encapsulating granules of herbicides in cornstarch as a way of preventing leaching. Have you done any work on that to determine whether it is a viable approach?

Dr. **Benbrook**. No, we have not done any specific, detailed assessments of encapsulation technology. Certainly there have been a lot of exciting developments in the area, and most recently with the use of cornstarch as a carrier. I think that in some cropping systems where the leaching of applied herbicides early in the spring when you tend to get a lot of your rainfall, in those kinds of areas, and under those circumstances, encapsulation can be an important option.

The problem with encapsulation, Senator Bond, though, is that it takes a certain degree of moisture to dissolve, if you will, the encapsulated herbicide active ingredient. If you do not get enough moisture at the right time, the herbicide remains locked within the capsule, and you have a breakdown in your weed control. So like any alternative practice or system or technology, there are problems and circumstances in which it will not work as well as it will when all things are perfect.

Senator BOND. You mentioned better use of agricultural inputs, and certainly that is something I think, at least, our farmers are most interested in where now we can apply pesticide in ounces per acre rather than pounds per acre. They see a very direct economic relationship. What are your views generally on the potential that biotechnology and what the use of natural occurring pesticides in the gene itself will do for a reduction in the use of pesticides and corresponding lessening of the use of chemical pesticides?

Dr. BENBROOK. I think in the near term the greatest potential for reducing the overall volume of pesticides applied in American agriculture will come from changes in management systems that just simply reduce the pest pressure. And in some cases, move a vulnerable crop into another area where there just is not a particular pest that creates a major problem.

And indeed, in many of the practices looked at in our report, the fundamental change in the farming system that made it possible to cut back on inputs was controlling a soil-borne plant disease or controlling an insect through various cultural and management practices to the point where the pest just was not there, and hence the farmer did not need to use the pesticide.

So in the near term, and by near term I mean the next 5, 10 years, I think the most significant reductions will be achieved through that avenue. However, farther down the road and in many of our fruit and vegetable crops which tend to be more heavily reliant on pesticides, there is great potential for the incorporation of genetic forms of resistance. In some cases, that is going to require and depend upon some new technique of biotechnology to incorporate a gene that brings about a higher level of resistance, and in other cases it will simply mean we are going to do a better job in selecting from the natural varieties of a crop the genetic characteristics that will confer a higher level of resistance.

But there is no question that farther down the road, we are going to be routinely building into crops a higher degree of genetic resistance to a lot of our basic diseases, but nature will keep changing and evolving. We are never going to totally solve these problems, but hopefully we are going to gain the capacity through a combination of practices—genetic, biological, chemical—to gain the ability to stay one step ahead of the pests.

Senator BOND. I might ask Dr. Nipp if he wants to comment. I did not mean to direct my questions only to Mr. Benbrook.

Dr. NIPP. Oh, not at all. I think one comment I would like to throw in, in regards to the economic profitability of alternative management practices in general, is that we may be coming in the next several years to an international environment in which we have no choice but to develop these kinds of production practices. A number of the people I speak with in the international environmental community have already figured out that it is a win-win situation for them in their respective countries. They can now go and sit down with the commodity groups and make the point that we can restrict the inflow of these outside commodities, not on the basis of economic standards now but on toxicological or food safety concerns that no one in their home country is going to disagree with them.

And we have already seen the situation with the European beef. We have seen the situation with citrus——

Senator **Bond**. And the blatant hypocrisy that goes along with those who use black market hormones in terribly unsafe amounts using the hormone scam as a way to keep out American beef.

Dr. **Nipp**. Precisely.

Senator **Bond**. Pardon the editorial comment.

Dr. **Nipp**. Well, I would concur, and I think this means that the research communities, the education communities are going to have to work very vigorously to develop cost-effective techniques if they are not already in place and to get the ones that we have out there because we have been talking about competitiveness and profitability for the last several years. Developing environmentally safe and toxicologically safe food production practices is going to be absolutely critical to compete on international markets in the next several years.

Senator **Bond**. I think that is a very important point. I appreciate your bringing that out.

Senator **Fowler**. May I interrupt here?

Senator **Bond**. Sure.

Senator **Fowler**. Dr. Nipp, we have—you have seen them—several national polls of farmers that reflect the fact that farmers overwhelmingly rely on agribusiness for their information on application procedures for pesticides, fertilizers, any of their chemical applications as opposed to the extension service. Should that be disturbing?

Dr. **Nipp**. Oh, I think it should be. I think the same polls——

Senator **Fowler**. Well, if it is, why should it be?

Dr. **Nipp**. I think the same polls also usually ask farmers to evaluate how well they regard the source of the information, how unbiased they feel it is, or what the quality they feel is of the information they are getting, and in those same surveys, information provided through the extension service is usually rated highest although it is often rated lowest in terms of the people they are actually going to for advice.

Now that is a very strange contradiction, and I think it reflects the fact that the extension agents out in the counties are trying to cover a broad array of topics. Water quality might be only one. They simply do not have the personnel or the resources to provide that one-on-one service that the much broader dealer community has the capability of doing.

Senator **Fowler**. Well, let me ask you this. Why is it that we get reports that so many extension service people in the field continue to criticize LISA and any alternative agricultural practices as things whose time has not come?

Dr. **Nipp**. Well, like all institutions we have a certain amount of inertia, and we would like to continue doing things the way we have done things, and we do not appreciate any criticism, implicit or otherwise, that maybe we have been doing things incorrectly. But I think, too, you will find a great deal of variation from one county to the next, from one State to the next, and I think official policy has been rather critical through the last several years. And the State and county officers have reflected that generic general policy.

As new resources become available, we are having some fairly religious conversions out there, and as people are having the opportunity to get access to new information and new funding, I think we are seeing a transition in the system, but I think we have both kinds of people out there.

Senator **Fowler**. You want to ask the last question?

Senator **Bond**. Yes, I want to ask one last question for both the gentlemen to comment on. We are looking at a number of things as we proceed with the 1990 farm bill, and I am impressed by the comments I get from my farmers back home who say that flexibility is absolutely essential for conservation, for water quality. I think, Mr. Benbrook, you touched on it when you said if you can alternate your crops and not lose your corn base or your wheat base, you can bring in, as we have now mandated in the disaster relief bill, crops that can have some very important benefits. I would appreciate both of your comments on it because I think it is going to be a very important battle, a very important issue for us to consider in the farm bill.

Dr. **Benbrook**. In crafting the 1985 farm bill, there was the convenient convergence, if you will, of the need to bring soil erosion under control and also help take a lot of land out of production because we had a serious surplus problem. I see in the 1990 farm bill an interesting and similar conversion of interest in building some base flexibility into the commodity programs.

The grain trade and commodity organizations want flexibility so that the American agriculture has the capacity to shift crop acreage around to meet soybean market needs, to expand oat production, to introduce new crops like canola, and the environmental community and the scientific community has been attracted to the concept of flexibility as advocated in our report on the grounds of the significant agronomic and environmental benefits to the farming system. And I think that there is absolutely no reason why a synergism between these goals cannot be captured. But it has to be done properly, Senator.

We have to provide farmers with the opportunity to use their base and probably combine their bases in a way that gives them maximum flexibility in what they do. Senator Kerrey is going to be proposing a return to the normal crop acreage concept. And I think many other——

Senator **Bond**. That is one that we have had frequently recommended in Missouri, too.

Dr. **Benbrook**. Many others will advocate that. So if you return to that concept and provide farmers with the flexibility to use that base in any way that they so desire, the next question becomes the level of government benefits that might accrue to a decision to plant corn versus soybeans versus oats. So one of the reasons that we have all been disappointed with the soybean acreage response to the 1989 disaster bill provisions, allowing up to—what is it—15 percent of feed grain base acres to be planted as soybeans. The reason that response was less than what some people had hoped is that still the economic incentive inherent in the deficiency payment for corn tilts the economic equation to planting corn instead of soybeans even though the world markets are crying for soybeans.

And with the oat target price so ridiculously out of line, no one is going to plant oats. And the Secretary of Agriculture, facing a similar situation with wheat stocks tightening up, went this year to an overbase provision which is really quite novel. So as part of the nuts and bolts of building base flexibility in, you have to sort of combine and then allow farmers to use the base. You have to get target prices and the economic incentives realigned so that even with flexibility farmers just do not plant the one or few program crops that are most generously protected.

And then you have to look at some of the other important questions like if a farmer has corn and wheat base now and wants to move to rotation where they grow canola or oats, are they going to get any payment during the part of the rotation that includes the canola or oats? If they are just given the opportunity to grow it, then you have a situation where the market price for new crops has to compete with a government-supported price.

Senator BOND. With a target price, yes.

Dr. BENBROOK. And I would submit to you that in many cases that is going to be a losing proposition. So I think that the Congress has got to bite the bullet and deal with some comprehensive reform of the pricing mechanisms and the ways in which farmers receive their benefits. And I think if that is done consistent with the recommendations in our report, you will see farmers going to more diverse rotations that are very profitable for them and help us meet market needs.

Senator FOWLER. Gentleman, I just have to cut off this very fine discussion because of our other panels. And we thank you both for your participation very, very much. Thank you.

We welcome our next panel, Mr. Ed Duskin from Southern Agricultural Chemicals Association; Mr. Jay Vroom from the National Agricultural Chemicals Association; Ms. Maureen Hinkle, the director of agricultural policy at the Audubon Society; Mr. Ron Rivinius, from the Wheat Growers Association. Ed, just anywhere here. Right, start right there. And Mr. George Wallingford from the Potash & Phosphate Institute.

Ladies and gentlemen, we welcome you. Again, I want to give at least a full hour to this panel. We have a lot of questions that will help us very, very much with the expertise here at the table. I would ask, as our other witnesses did, we have your full statements. If you could sort of summarize your initial presentation to 5 minutes. We will have a little light on here. That will give us 35 or 40 minutes afterwards to have some more discussion and question time. And I am also very interested—I will try to ask some of you—but I am very interested in what you have already heard from our first witnesses. Any reaction to anything that you have heard that you think ought to have another side presented or endorsed for that matter.

We will begin with Mr. Ed Duskin, who is the executive vice president of Southern Agricultural Chemicals Association from Dawson, Georgia.

STATEMENT OF EDGAR W. DUSKIN, EXECUTIVE VICE PRESIDENT, SOUTHERN AGRICULTURAL CHEMICALS ASSOCIATION, DAWSON, GA

Mr. **Duskin**. Senator, I am glad to be here from your native State.

Senator **Fowler**. You are the only Georgian. I do not want to be accused of stacking the deck here so go ahead Mr. Duskin.

Mr. **Duskin**. We appreciate the opportunity obviously to comment on the water portions of this bill and in general. We are a regional agrichemical trade association that covers all the basic manufacturers and formulators and distributors and some dealers in 13 Southern States. We have some overlapping membership with other associations certainly, but we also represent a large number of independent ag chemical sales agencies and small manufacturers.

VITALLY CONCERNED WITH GROUND WATER AND OUR PROBLEMS

We in the South, of course, are vitally concerned with ground water and our problems. We have some fragile soils, particularly in certain of our States. We think that drinking water protection should be the prime, or the major focus of legislation because other uses have varying degrees of protection or could have. We do not think that there is sufficient information available at this time, as many other people have said, to let us really get a handle on the extent, nature or exact causes of ground water contamination in particular.

"COORDINATED" RESEARCH PROGRAM IS AN ABSOLUTE ESSENTIAL

We know that there are specific areas in which there are hints of problems. But a coordinated, and I stress the word "coordinated" research program is an absolute essential. We must find out how this stuff gets into water, the susceptibility of our soils and how we can best continue our best farming practices and to keep our yields up and still protect the environment. We have simply got to have better information than we have now. It is out there. Various pieces are there. But a coordinated program we think is essential.

FINDINGS IN WATER

We also think that the public, as well as the grower, needs to be made better aware of the significance or even perhaps more so, the lack of significance of a mere finding of something in water. And without the, and I think the Government's role, and the EPA's in particular, is vital in establishing health advisories and eventually getting around to maximum contaminant levels which is a much more sophisticated program and getting this information out to the public.

We did this for a limited number of pesticides for the well water survey, but it needs to be much more far-reaching, and then not just have it, but have people get the word out so when something is found in a well—"Is this significant or is it insignificant?" "Do we have to worry about it?" We can find a million things to worry about. The unknown is really what we are more concerned about. We need to know what is safe, what is not safe, at least what is generally acceptable science. Well, certainly people will argue what is safe and what is not, but we need to have a basis for working on it.

So there needs to be a parallel education program to the grower on practices and how to keep from messing up things——

Senator FOWLER. And the public understands.

Mr. DUSKIN [continuing]. To the public on the other side.

Senator FOWLER. Yes.

UNIMPORTANT SUGGESTIONS

Mr. DUSKIN. We have great problems with some of minutiae in suggestions, particularly the idea of having fixed regulatory limits at which action will be taken. I think you had a 25 percent of preventative action level suggestion before action would actually be required. The idea of being able to look at what is happening, again it requires excellent State management programs obviously, monitoring programs. So that we can better know if we have a trend toward problems then we want the State to be able to take regulatory action to clear these up.

SUPPORT BEST MANAGEMENT PRACTICES

This does not mean that we do not do preventive type overall educational things and practices. So we support best management practices and ideas and selective State works. In other words, the State, we believe, should have the best—is the best designed to handle the program, to be able to take this area in a limited area and require special handling, if this is necessary to respect ground water in certain areas, but not gross across-the-board things that do not fit.

I think we can so decree in the question period. That might come in better on some of the comments that have been made. Thank you.

[The prepared statement of Mr. Duskin appears at the conclusion of the hearing.]

Senator FOWLER. Good. Thank you, Mr. Duskin, very much, and I would be remiss if I did not thank you personally as well as professionally for working with me and my staff on many of these tough conservation issues as we approach the farm bill. I know you have given up a lot of time on it, and I am deeply appreciative of your doing it.

Mr. Jay Vroom, executive vice president, National Agricultural Chemicals Association, Washington, DC.

STATEMENT OF JAY VROOM, EXECUTIVE VICE PRESIDENT, NATIONAL AGRICULTURAL CHEMICALS ASSOCIATION, WASHINGTON, DC

Mr. VROOM. Thank you, Mr. Chairman. We appreciate this opportunity to be here and echo all of what Ed Duskin has just presented and will abbreviate our remarks here as well and ask that you enter our advance statement in the record.

IMPROVEMENT SHOULD CONTINUE TO BE OUR GOAL

We commend you for your continued interest in looking for ways that the Congress can enhance American farmer efficiency and productivity while improving domestic agriculture and our environment. We do have a wonderfully abundant food production system in this Nation. Today, this system performs, we believe, in a manner that is, for all intents and purposes, environmentally sound. We want to be better environmentally. We certainly want this on behalf of the manufacturers of crop protection chemicals. We also want the quality of our food to continue to be improved as it has been over the recent decades.

WE MUST ALSO KEEP REALITY BEFORE US

Certainly our farmer customers want all of this, and obviously those leaders in government like yourself have that common objective. There is resolve across all lines that improvement should continue to be our goal, but we must also keep reality before us.

Our existing system of food production and fiber production is imported by a phenomenal system of technology, technology that has enabled our food production in my lifetime in the United States to be more than doubled over the last four decades, while the input of labor on the farm has been reduced by some 75 percent. We cannot overnight throw out all of this technology and expect our abundant and safe food supply, available to all consumers at reasonable prices, to continue. We are much closer to the world's thin line of hunger than we sometimes remember.

USDA estimates tell us that our American wheat stocks-to-use ratio has not been lower than it is now since the early 1970's. Other statistics say that some world grain stocks-to-use ratios are lower than in all of recorded mankind's history. The continued judicious use of existing technologies to keep us above the thin line of hunger in this big world are essential and provide the necessary incentive for the continued research and development investments by my members and others involved in providing other types of technology for farmers today and in the future.

WE ALSO NEED TO BE CAREFUL ABOUT THE INFORMATION THAT WE RELY UPON

We also need to be careful about the information that we rely upon, as Ed has just said, about making those risk-benefit decisions with regard to the technology and how it is being deployed today and tomorrow. Sketchy, partial information on ground water detection levels must be carefully examined and viewed with proper perspective.

BIG SPRING STUDY

We would call again your attention to the Big Spring study that was referenced in our advanced testimony. We would like to supply a copy of this to you if you do not have it already, and certainly provide it for the record if you so desire.

The Big Spring study originally out of northeast Iowa, the preliminary data showed that there were alarming trends that appeared to be on the uptrend with regard to detection of certain crop protection chemicals, in particular, certain long-lasting and persistent herbicides.

But as the data continued to be accumulated over the ensuing years of the study, it showed that those detection levels in the early years were really aberrations. In addition to learning more and better facts about the condition of our ground water, we all have an obligation to continue with good educational efforts for crop protection, chemical users, about the safest possible means of using existing technology and getting the most out of it for the efficiency of the farmer's dollar as well.

COOPERATING CLOSELY

This is a job for our industry. It is a job for government, the extension service and the various agencies. We and our members are cooperating closely with EPA, USDA, and many State, local and other Federal agencies in expanding research and coordination education efforts. One major new example of this area undertaken by our industry is the development and debut in the last year of the Alliance for a Clean Rural Environment, or ACRE, which has been supported by virtually all the major crop protection manufacturers, an outreach program aimed at the grassroots level of getting information in the hands of farmers about the safe and judicious use of pesticides.

We encourage your subcommittee and the rest of your colleagues in the Senate and the rest of the Congress to take a balanced and calm approach to the complex issues before us with regard to all ag environmental issues and ground water, in particular. We believe that you have done so with the beginning and commend you for your efforts, and we look forward to working with you in finding the best path forward with regard to ag environmental issues. Thank you.

[The prepared statement of Mr. Vroom appears at the conclusion of the hearing.]

Senator **Fowler**. Thank you, Mr. Vroom, very much.

Maureen Hinkle, director of agricultural policy for the National Audubon Society. Welcome, Ms. Hinkle.

STATEMENT OF MAUREEN KUWANO HINKLE, DIRECTOR, AGRICULTURAL POLICY, NATIONAL AUDUBON SOCIETY, WASHINGTON, DC

Ms. **Hinkle**. Thank you, Mr. Chairman, Senator Baucus. The National Audubon Society appreciates this opportunity to present our views on the critically important issue of ground water. I have to note that this is very unusual for me to appear on a panel with the people that I am surrounded with. Normally what comes between a pesticide and a crop is a pest. I hope you are not trying to tell me something.

Audubon is a nonprofit conservation organization. We commend you for your leadership in making ground water protection a central issue in the 1990 farm bill debate, and we are very pleased that Senator Baucus brings his knowledge of ground water to this committee at a critical time.

GROUND WATER CONTAMINATION INCREASES AS WELL AS THE NUMBER OF PESTICIDES THAT ARE FOUND

My testimony goes into the importance of ground water, the occurrence data that shows that every 2 years the number of States with ground water contamination increases as well as the number of pesticides that are found.

A TREND WHICH HAS TO BE REVERSED

We believe there is a trend which has to be reversed. In the last 20 years the use of pesticides has tripled, and we think that this cannot go on any longer now that we know that the mechanisms for transport of agricultural chemicals to ground water is becoming clear. What is perhaps the most striking aspect of this new understanding of ground water contamination and its mechanisms is the potential scope of contamination. Contamination is a result of normal farming activities. 1,437 counties have been identified by USDA as being possibly vulnerable to ground water contamination with pesticides or nitrates. We think that we must reduce this trend, we must reduce the threat of contamination at its source, and that this can be done only reducing the use of potential contaminants used in agricultural production.

WE BELIEVE THAT EVIDENCE SUGGESTS THAT FARMERS ROUTINELY OVERFERTILIZE THEIR CROPS WITH SYNTHETIC FERTILIZERS EVEN WHEN THEY SIMULTANEOUSLY APPLY MANURE TO THEIR FIELDS

As we noted in testimony on September 21 before another Senate subcommittee, we believe that evidence suggests that farmers routinely overfertilize their crops with synthetic fertilizers even when they simultaneously apply manure to their fields. Pesticides have similarly been applied unnecessarily. So we believe that reduction—we do not think that it should be gross across-the-board kind of thing that Mr. Duskin spoke of. We think that reduction is possible, and that this is a logical first step in the protection of the Nation's ground water from agricultural contaminants.

WE IDENTIFY VARIOUS RESEARCH NEEDS

We identify various research needs. All of them are multidisciplinary, and all of them have more to do with agricultural research rather than the hydrologic aspects of ground water contamination.

DATA COLLECTION, RELIABLE USE DATA AND ANALYSES ARE ABSOLUTELY VITAL TO ASSESS PROBLEMS

We also believe that data collection, reliable use data and analyses are absolutely vital to assess problems and to verify the extent of pesticide residues in both food and water, which are of high concern to the American public today.

Without adequate and reliable information, EPA will have to rely on guesswork, and as we know, it has been the farmers who have to pay the price in the regulatory arena for lack of information about pesticide use. So our statement goes through how and in what ways this accurate and comprehensive data base could be obtained and how it could be used.

EDUCATION AND TECHNICAL ASSISTANCE

We believe that education is very important, but we think that more than just education is needed. Farmers will need technical assistance. Many farmers would be very glad to protect their ground water, but they do not know how, and unless incentives and disincentives are put in place, they will have to continue to rely on chemicals.

A major technical assistance and education program will be needed, and it is going to have to be comprehensive. In regard to regulation, I believe that without an effective program of ground water protection more and more States will take matters into their own hands. Just as Florida regulates agriculture as a point source polluting industry, other States may also follow suit. And I wonder if we really do want more and more States to address ground water in a variety of different ways.

A MORE COST EFFECTIVE WAY IS TO REDUCE THE POSSIBILITY OF CONTAMINATION

Audubon believes that a more cost effective way is to reduce the possibility of contamination, and we look forward to working with you in developing the incentives and disincentives in the 1990 farm bill. Thank you.

[The prepared statement and attachments of Ms. Hinkle appear at the conclusion of the hearing.]

Senator FOWLER. Thank you, Ms. Hinkle, very much.

Mr. Ron Rivinius, secretary-treasurer of the National Association of Wheat Growers from Elgin, North Dakota. Welcome.

STATEMENT OF RON RIVINIUS, SECRETARY-TREASURER, NATIONAL ASSOCIATION OF WHEAT GROWERS, ELGIN, ND

Mr. RIVINIUS. Thank you, Mr. Chairman.

Senator FOWLER. You have some snow already; do you not?

Mr. RIVINIUS. No. We have had probably warmer temperatures than here. We are still very dry.

Senator FOWLER. Sorry to hear that. I will pass that on.

BACKGROUND

Mr. RIVINIUS. Mr. Chairman and members of the subcommittee, my name is Ron Rivinius, and I am an officer of the National Association of Wheat Growers. My family and I operate a wheat farm in Elgin, North Dakota. I am pleased to address the subject of water quality and agriculture today, and I am also speaking on behalf of the National Cotton Council, the National Corn Growers Association, the American Soybean Association, and the U.S. Rice Producers Legislative Group.

WE HAVE SEEN THAT AGRONOMIC RESEARCH AND DEVELOPMENT HAS BEEN INCREASINGLY FOCUSED ON ENVIRONMENTALLY SOUND CROP PRODUCTION SYSTEMS

In response to the environmental concerns of farmers and the American public, we have seen that agronomic research and development has been increasingly focused on environmentally sound crop production systems. For example, soil and water conservation concerns led to the development of low till technologies, and widespread adoption of them by farmers during the past decade.

More recently, the scope of environmental concerns relating to agricultural practices has been broadened to include water quality. We have learned that ground water in certain regions is vulnerable to contamination by some of the fertilizers and pesticides now in use. We must, therefore, encourage significantly expanded research in order to understand how these necessary nutrients and crop protection products can be used more precisely in order to lessen their environmental impact. Research results must then be translated into management packages that can be demonstrated to farmers, and adapted to specific cropping practices and field conditions.

USDA HAS OUTLINED A RESEARCH PLAN TO GATHER GROUND WATER DATA TO ENABLE ITS SCIENTISTS TO BETTER UNDERSTAND THE IMPACT OF AGRICULTURAL PRACTICES ON WATER QUALITY

USDA has outlined a research plan to gather ground water data to enable its scientists to better understand the impact of agricultural practices on water quality. This very important research should be supported with the additional funding it will require. USDA also proposes to field test a variety of technological and management options designed to lessen the environmental impact of agricultural chemicals while maintaining profitability, and to sponsor demonstration projects to introduce the techniques to farmers.

Demonstration projects such as these should lead to more institutionalized technical assistance programs that are focused on environmental protection. An effective delivery system to farmers for expanded water quality technical assistance program must be designed, utilizing the existing SCS, ASCS, Extension and local conservation districts infrastructure.

MORE AND MORE FARMERS ARE SEEKING OUTSIDE EXPERTISE FROM AGRONOMIC SPECIALISTS ON IMPROVING INPUT EFFICIENCY

Individually, more and more farmers are seeking outside expertise from agronomic specialists on improving input efficiency, including fertilizer and pesticide timing and application rates for specific crops and field sites. For example, in our State of North Dakota in the eastern part where it is intensely farmed, fertilizer blends and herbicides can be variably applied based on soil maps generated by computers from infrared photos. Using soil tests, grid maps and survey maps, farmers are finding that such technical services can often provide advice that makes good economic sense, which means that they can maintain yields while they are lowering their inputs.

RESOURCES

Without question, resources directed toward environmental research and the development of an appropriate technology base for efficient agriculture production in environmentally sensitive areas must be increased. Limited funds must be directed toward geographic areas where soil types and ground water depths indicate vulnerability to contamination. In general, these are being identified without the need for new federally funded well testing programs. Under Clean Water Act responsibilities, States are already in the process of identifying and monitoring areas with "impaired waters," including surface and ground waters.

WELL TESTING

We encourage farmers to have their wells tested if they have reason to believe their wells may be contaminated with chemical or bacterial agents. Well testing is usually available through county health departments or other sources. However, we do not believe that a federally mandated program of individual well testing is the key to a meaningful ground water protection strategy in agriculture. So we oppose mandating well testing or legislating voluntary well testing for producers.

EDUCATION

We concur with the recent findings of the Economic Research Service study on ground water that: "Farmer education, backed by well documented research, will be a major and cost-effective strategy in preventing or minimizing ground water contamination, as opposed to the monitoring and remedial action approach, the costs of which are potentially significant and would largely fall to the rural sector."

COOPERATIVE APPROACH

In short, the cooperative approach which has been effectively taken for decades in implementing conservation and erosion control programs on cropland should be utilized to address water quality protection. Without linking water quality initiatives in any way to commodity programs, practical expertise should be made available to the farmer within the delivery system that is familiar and usually accessible to him.

I thank you for your time, Mr. Chairman.

[The prepared statement of Mr. Rivinius appears at the conclusion of the hearing.]

Senator FOWLER. Mr. Rivinius, let me thank you also in your representation of all the commodity groups that you mentioned, for all of you being extremely cooperative with me and my staff as we identify these problems and work through these problems. As you know, though, it is always subject to change. That is what these hearings are all about. The well testing program is the only thing in my legislation that is mandatory in spite reports to the contrary.

But we are still, that is why we are here today. We want to examine that. Should we do it, how should we do it, and who should do it? So I thank you for your continued working with us.

Dr. George Wallingford, Potash & Phosphate Institute from Columbus, Ohio. Welcome.

STATEMENT OF GEORGE W. WALLINGFORD, POTASH & PHOSPHATE INSTITUTE, COLUMBUS, OH, ON BEHALF OF THE FERTILIZER INSTITUTE, WASHINGTON, DC

Dr. WALLINGFORD. Thank you, Mr. Chairman. It is a privilege to testify today, and I trust that the committee serves quality water because I am going to be taking more home with me than I originally intended. [Laughter.]

Senator BAUCUS. Say something about that.

Senator FOWLER. We will start with testing our own. You are supposed to drink it.

Dr. WALLINGFORD. Well, that was the intent.

RESEARCH

Like this subcommittee, Mr. Chairman, the fertilizer industry, too, is an active partner in agricultural research, having a keen interest in the safe use of agricultural inputs.

Since 1980, PPI, or the Potash & Phosphate Institute, has funded over 250 research projects in 37 States, exceeding the total outlay of $3.5 million.

THE VAST MAJORITY OF DATA SHOWS THAT OUR UNDERGROUND WATER SUPPLY IS SAFE

I also share the committee's concerns about water quality. However, the vast majority of data shows that our underground water supply is safe.

For example, in my home State of Ohio, a recent survey of over 14,000 wells showed only 2.7 percent had nitrate levels exceeding water quality standards.

Senator FOWLER. 2.7 out of how many?

Dr. WALLINGFORD. 2.7 percent out of 14,400-and-some wells. Factors such as the age and depth of the well had a much greater effect on contamination than did the well's proximity to cropland. In other words, the least contamination was found in that part of the State which has the most intensive agriculture.

RESEARCH

Regarding research needs, Mr. Chairman, research will continue to play a key role in identifying and correcting problem areas. And further research is certainly needed. Specific objectives are included in my report that I have submitted.[1]

EDUCATION AND TECHNICAL ASSISTANCE

Regarding the transfer of technology to the farmer, Mr. Chairman, the current process is too slow and simply must be improved. Technologies are still not being used today that years ago were proven to be profitable and environmentally safe.

For example, many proven best management practices are not being transferred to the farm. Some examples include improved fertilizer application techniques which reduce nitrogen leaching; crop rotations which reduce the need for applied nitrogen; and conservation tillage techniques which dramatically reduces soil erosion.

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[1] Conventional and Low-Input Agriculture, see pp. 136 to 187.

These same BMP's are now touted by low-input advocates as new ideas. In reality, scientists for decades have been investigating these and other technologies which reduce pollution. Many farmers now use these BMP's on their farms. The need is for improved educational programs to convince more farmers to use them. The Extension Service has been devastated by budget cuts, preventing it from fulfilling its educational mission, a mission I feel it is still quite capable of carrying out if it is provided with sufficient resources.

DATA COLLECTION

Regarding data collection, Mr. Chairman, good information is critical to understanding ground water contamination. The Ohio well survey mentioned earlier is a good example of this, but we need more and better information because the lack of accurate information hampers farmers and others from making good land use decisions.

We should be aware of other related information that is already available. Regarding earlier comments about fertilizer use statistics, in your home State, Mr. Chairman, the Georgia Department of Agriculture annually reports amounts of fertilizer use on a per county basis. In the home State of this subcommittee's Ranking Member, the University of Missouri also reports fertilizer use on a county-by-county basis as do the majority of other States in the country.

I believe the current system works well and provides sufficient accounting of fertilizer use. National fertilizer statistics are also available from TVA's National Fertilizer Development Center and USDA. So data collection should rather focus on further ground water testing and monitoring which nets the most usable knowledge.

REGULATION

Regarding regulation, Mr. Chairman, further research and education and not regulation is the key to preventing ground water contamination. Already rural communities are strapped with expensive regulations. EPA estimates that environmental regulations cost residents of small communities $170 more per person for essential services that urban residents. And EPA concludes that further regulation may force many farmers out of business. I trust this committee will keep this in mind as it considers regulatory options.

GROUND WATER POLICY SHOULD BE BASED ON SOLID FACTS

In conclusion, Mr. Chairman, I believe that ground water policy should be based on solid facts. By improving research and education, we can generate the needed information and show farmers how to protect water quality. I am submitting for the record a more detailed analysis of best management practices and copies of both the Georgia and Missouri State Fertilizer reports. Again, thank you, Mr. Chairman, for this opportunity.

WHY SOME EXTENSION PEOPLE ARE NOT SUPPORTIVE OF ALTERNATIVE AG TECHNIQUES

And you asked that we address previous comments, I thought I might just make a couple of brief comments on a couple of things if we have time regarding why some extension people are not supportive of alternative ag techniques.

Senator **Fowler**. Please. I'd be very interested.

Dr. **Wallingford**. Well, my impression of that is simply there is not enough facts yet to allow extension agents whose responsibility it is to provide the very best information to farmers to justify many of the alternative agriculture techniques that are being talked about. Extension's charge is to present the facts based on research and simply there is not enough research yet that has demonstrated that many of the alternative agricultural practices are any better for the environment than what has been recommended and developed over many years of research and science.

[The prepared statement and attachments of Dr. Wallingford appear at the conclusion of the hearing.]

Senator **Fowler**. Well, with all great respect now, I do not know how you can say that. It is the other side of the coin. In your testimony, I was trying to listen very carefully, talking about how we had all these, how the technology has been there, that these new ideas are not really new ideas, and somehow it is just not getting to the farmer, and we need to explore that, whose fault that is and where we can do a better job leaving fault aside.

But I do not think that you can say that 3,000 years of agricultural history and conservation practices and crop rotation and windbreaks, these have been around an awful long time. People have been feeding themselves for thousands of years. There is nothing new there either. What is new is the enormous benefit on short-term benefits certainly for—depending on how you define short term—on what energy and chemical use can do if you do not look at what happens to the land and what happens to the water, if you put on excess amounts for long periods of time, and do not use techniques that are as old as farming themselves. Would you not agree with that?

Dr. **Wallingford**. Well, I think we have made tremendous progress in adopting——

Senator **Fowler**. And these things are not unknown to the Extension Service.

Dr. **Wallingford**. But they have done an excellent job of convincing many farmers to use them. And I guess many of the techniques such as use of legumes and increased use of animal manures to provide nutrient sources present many more risk factors in my mind in terms of being able to control nitrate leaching than does the use of commercial fertilizer. You cannot control the release characteristics of when the organic nitrogen in manures and legumes are going to be made available to crops.

Often they are made available later in the crop-year after the crop needs them. So they are much more difficult to handle from an environmental standpoint than the commercial fertilizer. And environmentally I see much greater risk from using some of the alternative practices than what farmers are now doing.

Senator FOWLER. Thank you. Mr. Duskin, following a little bit up on Dr. Wallingford's observations, you also mentioned the best management practices in your testimony and just heard his observations. How do you evaluate the efforts in our State, in Georgia, of the Extension Service in educating farmers on best management practices?

Mr. DUSKIN. I think we have a way to go, but it is probably one of the better States, in my opinion, and certainly we have farm land down around Dawson and Randolph Counties of our own. That brings back the point that was raised before.

Senator FOWLER. Is it the best or can you make that evaluation of the five or six States that your organization represents?

Mr. DUSKIN. It is among the best, I would say. They have been covering for a long time the idea and conservation techniques are certainly—crop rotations are routine in all of the Southeast for that matter. And you utilize your fertilizers and even to some because you have to avoid land that has certain pesticides used on them for the same, to keep it. But that has just been standard practice.

Senator FOWLER. Which of the States in your opinion that you know so well through your organization, which have the most successful water quality programs and do they use well testing and how do they do it?

Mr. DUSKIN. Florida has an excellent program. It still has a way to go because they have very fragile soils in much of that State. Georgia is just getting, moving well into a well testing program. Alabama has a ground water strategy that they are just beginning to implement. However, the Geological Survey in both States are working very closely with the Department of Agriculture and the Department of Natural Resources to get a better handle on all of the water issues and problems.

As you know, in Georgia, the Governor's growth strategies bill tied in watersheds and several areas like that, and it will extend into actually checking and looking strongly at the aquifer recharge areas. All of these have excellent programs.

Senator FOWLER. Mr. Rivinius, does North Dakota have a water quality program for agriculture? Does it involve well testing or some other form of data collection?

Mr. RIVINIUS. They are just getting into that. The State of Minnesota has——

Senator FOWLER. Now what is that? Clear it up. Does that mean they are just beginning to look at it or they passed a State law that is actually doing it?

Mr. RIVINIUS. No, they are just getting——

Senator FOWLER. Just looking at it.

Mr. RIVINIUS. Looking at it and probably during the next legislative session there could be some action taken. But the State of Minnesota has passed some strong water quality legislation.

Senator FOWLER. You heard all the other testimony, asking almost unanimously for flexibility in the commodity programs as we look at the 1990 bill. I would like your observations. Do farmers need more planting flexibility in this regard so that they could try some alternative agricultural methods that might be fruitful from a conservation perspective?

Mr. RIVINIUS. I think the flexibility would——

Senator FOWLER. In other words, let me just make it plain. As we say at home, put the hay down where the goats can get it. Do the present programs, since you are a farmer, force the farmer to basically farm the government?

Mr. RIVINIUS. You are correct.

Senator FOWLER. Thank you. Now go back to the first part of it.

Mr. RIVINIUS. Greater flexibility would help us with our weed control and pest control. We need some flexibility to plant other crops without losing our program base and payments on our program crops.

Senator FOWLER. Dr. Wallingford, what do you—again, I heard your testimony on what you want, this county to county testing and no regulations. We hear that often and everywhere. How should we do it? How should we improve our current methods of data collection on water quality? Are you saying the Federal Government has no role in that? I am not trying to put words in your mouth. Are you perfectly willing to just rely on piecemeal the way it is being done now in county to county and some States do it and some States do not?

Dr. WALLINGFORD. Well, the nature of ground water contamination is very site specific.

Senator FOWLER. The contamination is site specific, but once whatever is in the water does not stay in the county.

Dr. WALLINGFORD. Well, it stays——

Senator FOWLER. It goes to the next county and then it goes to the next county.

Dr. WALLINGFORD. It depends on the aquifer characteristics how far it moves.

Senator FOWLER. I understand.

Dr. WALLINGFORD. But generally it stays within the same general area of where the contamination originally occurred. I think any system should be based on identifying those parts of the country that are susceptible to ground water contamination and concentrating our efforts on those areas. And any broad-brushed type of efforts, I believe, could be counterproductive because we might be forcing practices on probably the majority of our farm ground which really have no real benefit. So I think we should——

Senator FOWLER. Well, let me ask you this. Your own, half of our industry is saying we do not need any more, saying we do need more research before we jump into these areas that we are discussing such as low input and IPM's. Are we going to get some industry support from you for increased research dollars in these areas?

Dr. WALLINGFORD. Well, we would like to increase it as much as feasible, and we have, as I indicated earlier, we spent several million dollars in the last few years on——

Senator FOWLER. Is that a yes or a no? [Laughter.]

How much is feasible?

Dr. WALLINGFORD. Our intent is good. And that is about all I can say. But I think certainly the industry sees the need for increased industry involvement in identifying those areas which need further work. And again, it is a very site specific area and in some ways perhaps the States are better able to identify those areas because of their better connections with their own local conditions.

Senator FOWLER. Mr. Vroom, as you know, there are some farmers—I will not get into a debate here on how many for a moment—but as we have gone around the country and held hearings in seven or eight States, we have had testimony about farmers, from farmers worried about the possibility of carcinogens, possible carcinogens in their drinking water.

Do you feel that this worry is just a perception problem and does your association support well testing for drinking water on farms as a means of data collection and getting a data base to see whether there is a problem?

Mr. VROOM. I will answer your second question first, if I might. Yes, we do support well testing where there is legitimate reason to believe that we do have a spot or a particular problem. We think most of the contamination situations with regard to crop protection chemicals can be traced back to and have been driven by point source contributions, accidents, spills and the like and not from normal agricultural field use of those products according to the label directions.

We do not support an endeavor funded by anyone that would mandate that every well be tested for every conceivable product because of the enormous costs, as others have said today. That kind of system no matter where that would have to be funded from, and if it came from the Government, which often is the easy and pat answer, it would have to obviously come out of other program funds with the constraints that you face with regard to the Federal deficit.

So we think that we can identify and anticipate where problems are and do support targeted sampling on a very reasonable kind of a basis.

Senator FOWLER. Well, what about your support, your industry's support of expanding the Conservation Reserve Program with specific targeting of water quality such as the inclusion of sink holes or other environmentally sensitive areas?

Mr. VROOM. We think that that has a lot of merit, and again it is dangerous to blanket endorse a concept or program that does not have specifics attached to it, but we would be happy to work with you and in particular, I think, most importantly our farmer constituents, the organizations that Mr. Rivinius represents here this morning, who are among the leading organizations, along with the national farm organizations, who understand the implications of those kinds of programs and can work with all of us to make those kinds of policy decisions.

We think that there is merit in that kind of concept of targeting the CRP as it moves forward on environmentally sensitive areas, but again, we would not offer a blanket endorsement of that concept.

Senator FOWLER. Let me ask you this. Excuse me. I am sorry.

Mr. VROOM. I wanted to go back to your first question with regard to farmer concerns about the presence of detected amounts of pesticides, particularly those that are suspected human carcinogens in their drinking water supplies. That is a very realistic concern. One that I share being reared on a farm from central Illinois where my family still farms and drinks that water. It is a concern on the minds of people who live in those communities and drink and depend on ground water sources for their drinking water.

We have to keep perspective with regard to that concern. I think better information about what a mere low level detection means with regard to health effect needs to be explained to those people who are now beginning to have a growing awareness because of the public perception and visibility of these issues, and separate the perception of what a detection means from a detection that might be above the health advisory level for suspected carcinogens and other crop protection chemicals and other contaminants alike. There is no such thing as pristine and absolutely pure water anywhere with regard to commercial and drinking water supplies.

And we need to keep that kind of proper perspective and get that kind of information into the hands of people who do have those concerns so they can understand what they need to be concerned about and what needs to be focused on and corrected.

Senator FOWLER. Ms. Hinkle, do you think farmers are concerned about contaminants in their drinking water?

Ms. HINKLE. I think there is significant evidence that they are. For a long time farmers thought that their ground water resources were pure and were so deep and cold and naturally cleansing that they would never be contaminated, and I think it has come as a shock to them that the water they have to drink everyday has pesticides detected in many areas.

Senator FOWLER. Is a reliance on best management practices enough, in your opinion, to maintain safe quality water?

Ms. HINKLE. I think that when we look at the use of pesticides as they have come to be put on the same acres in the last 20 years, with more and more put on each acre, it should come as no surprise that we have ground water contamination. And until recently we did not have continuous cropping, or monocropping. We used to have crop rotations. So I think that it is logical to conclude that if rotations were made possible for farmers, and I agree with Mr. Rivinius that if farmers could maintain their bases, rotate their crops, and not lose money, they would be happy to do this. And if they knew that they were protecting their ground water in the process, I think they get a double benefit, and I would hope that such incentives could be put in place in the 1990 farm bill.

Senator FOWLER. Mr. Vroom, back to you for a moment. You have heard all the questions basically that I have asked this morning about the Extension Service and their responsibilities in this area. I think that we all agree based on the testimony this morning from various perspectives that farmers rely on agribusiness for their information regarding chemical and fertilizer applications. And while this says a lot for agribusiness' abilities, it also makes us, I think, reevaluate what we should be doing in encouraging and educating through our Extension Service. A practice has recently come to my attention that you may or may not know anything about, but I thought I would ask you, of chemical companies paying consulting fees to the Extension Service specialist, who are then, of course, called upon to implement education policy in areas that directly relate to your industry.

Do you know about this and is this a good practice?

Mr. **Vroom**. I am not acquainted with any particular situation or system by which Extension Service agents are hired as independent consultants while they continue as agents of the Extension Service. Certainly our industry in developing and providing and advancing recommendations to farmers with regard to management information in the use of our products, much the same as the fertilizer industry does, relies on references, university conducted research data, to make those kinds of recommendations.

So I think the cooperation that exists between the manufacturers of fertilizers and crop protection chemicals and the Extension Service and land-grant universities' research is integrated and it is used by farmers to cross-check the source, one to the other. And I do not think one necessarily has compromised the other.

Senator **Fowler**. Let me ask you this last question, and then I will turn it over to Senator Baucus and Senator Gorton. I do not want you to take this as a hostile question, but I think we need to ask it and tell me what you see as the future. The American Farm Bureau testified at a joint hearing in the House of Representatives on October 3 that the integrated pest management is a high priority for the Farm Bureau. Their statement pointed to a 38 percent reduction in pesticide use by New York apple growers; 66 percent reduction of insecticide use on onions in Texas and cotton programs, so on.

If IPM were to be implemented on major crops, and continued to result in such reductions, what would be the impact on your industry? Are you preparing for that, and/or faced with the possibility of 40 or 50 percent reduction in the chemical usage, if that were possible, would you be fighting it?

Mr. **Vroom**. I think the record of my industry, in particular, the research based companies in our industry, who are the leaders in the industry with regard to development of new products, has been to favor and advance new technology and reconfiguration of existing technology that makes the best economic and environmental sense for our farmer customers. I do not think that it is fair to accuse my industry of having lost touch with the fact that our support and income comes at the success of our farmer customers.

So we are not ready to stand in the way or throw roadblocks in the way of progress with regard to use of existing technology or future technology that is good for our farmers' business, good for food consumers and good for the environment. So we would not throw a wet blanket over that concept, but on the other hand, I think that the crops that you referenced out of the Farm Bureau testimony are those kinds of crops, specialty crops, that have perhaps had the most potential benefit from reduced pesticide use, implementing integrated pest management, and that a larger commodity like field crops probably have less percentage kind of reduction potential from larger implementation of IPM than the specialty crops have had because they are so intensively farmed. But I cannot react beyond that without really looking at additional specifics.

Senator **Fowler**. Thank you. Senator Baucus.

Senator **Baucus**. Thank you, Mr. Chairman. Gentlemen, we all know the importance of agriculture. In fact, agriculture is the biggest industry in my State of Montana and we have to very aggressively produce if we are going to stay alive because of international problems we face. That is European Common Market, Canada and other countries very dramatically subsidize their production, at least in the product I am familiar with, wheat. And it is important for us to meet the competition.

Nevertheless, there is a great concern about water quality as a result of all crops and other sources, too. It is not only agriculture, but there are sources that tend to potentially or actually contaminate our underground water system. I would like to ask the panel some questions. Do you think there is a water quality problem that requires congressional action? Is there a water quality problem in this country that current law does not adequately address and therefore additional legislation is necessary?

Mr. VROOM. Well, I will begin, Senator. I think that it is our perspective that there is an important difference in characterization and to call it a national problem, we would object to. But we do recognize that there are individual spot specific problems that do need remedial——

Senator BAUCUS. Well, whether it is individual or national, is there enough of a problem that it requires congressional action?

Mr. VROOM. I do not believe that we need congressional regulatory action at this time. We do need additional support on research and monitoring.

Senator BAUCUS. You mean support in addition to what is already addressed to the problem? That is, resources in addition to what is already addressed to water quality research?

Mr. VROOM. Limited additional research dollars certainly are appropriate in this area.

Senator BAUCUS. Additional public research dollars. Is this an implied admission that there is enough of a problem that requires additional congressional action?

Mr. VROOM. No, I think we can always do better, and additional research is also welcome and is the mainstay of American agriculture.

Senator BAUCUS. Unfortunately I have an 11 o'clock appointment with the Majority Leader. So we are going to have to do this very quickly.

Ms. HINKLE. Without a dramatic turnaround in agricultural practices, I believe that regulation is inevitable, and that this regulation will be harmful to the farmers. I think it will be costly. Remediation will be costly, and regulation is normally——

Senator BAUCUS. Dr. Wallingford, do we need additional congressional action?

Dr. WALLINGFORD. I believe we do. I believe there——

Senator BAUCUS. Where?

Dr. WALLINGFORD. In the area of research. That is where we need it.

Senator BAUCUS. What about private research? How much—let me ask Mr. Vroom and Mr. Wallingford—what percent of the chemical and phosphate, potash and so forth, industry devotes, what percent of its budget is R&D to developing safer ways, less toxic chemicals, et cetera?

Mr. VROOM. Well, in our industry's case we are again in the research based companies small divisions, although large business is small divisions of major multinational diversified companies and across the board——

Senator BAUCUS. I am going to have to leave. What percentage of your R&D is devoted to this problem?

Mr. VROOM. Across the board our ag chemical divisions are spending at least twice the average of the rest of the corporate R&D commitments.

Senator BAUCUS. Is it increasing or is it steady?

Mr. VROOM. I would say that it is relatively steady to slightly on the increase but a lot of that is tentative based on just what kind of regulatory threats are facing the incentives to bring on new products that have to face higher hurdles of health and environmental fate considerations.

Senator BAUCUS. OK. I have a lot of questions, but I have to leave. I would just encourage us to find a common solution. I am reminded a bit of a recent article I read called "The End of Nature"—it was in the New Yorker magazine about a month ago—which I thought was very compelling. Namely, nature is not infinite. I think you alluded to it yourself, Ms. Hinkle, when you said that farmers used to think that their ground water was always safe. After awhile a lot of farmers are realizing it is no longer safe.

It is like weather. Whether we have a hot day or a cold day or it rains or does not rain, I think no more is an accident of nature. Humans are starting to influence the weather. And I think the same trend, the same phenomenon is probably starting to occur in most other areas including quality of water, which means that we are going to have to find some common solutions.

We have to continue to produce our crops. There is no doubt about it. We have to do it in a way that addresses some of these problems. Frankly, I encourage all of you in the industry to devote additional R&D to solving this problem because once you do, then you will be on the solution. You will not have a solution dictated to you. Thank you very much.

Mr. DUSKIN. On the regulatory side of things, Senator Baucus, you have in your State, just put in place, one of the better, we feel, of the ground water regulatory plans. It is balanced. It covers all areas, and I would commend it to others to look at.

Senator BAUCUS. Thank you. Thank you, Mr. Chairman.

Senator FOWLER. Senator Gorton.

Senator GORTON. I came in in the middle of this. I will skip the questions on this panel.

Senator FOWLER. All right. Before I dismiss the panel with my thanks, anybody want to react to anything that has been said? I always like to—yes, sir?

Dr. WALLINGFORD. Regarding the source of information——

Senator FOWLER. No speeches you understand?

Dr. WALLINGFORD. I understand. Regarding the source of information. You mentioned the farmers go to industry a good bit for their information. That is true, but I would to emphasize what Mr. Vroom said about the original source of that information is the Extension Service and the land-grant universities. And what, for instance, what the Potash & Phosphate Institute puts out in our educational efforts, that is, the original source of that is our Extension

Service and the land-grant universities. So that is the source. And that is true of almost all industry recommendations.

Mr. **Vroom**. I would concur with that and point out that having worked for the Cooperative Extension Service in Illinois myself before coming to Washington and still having a lot of friends who remain dedicated to working within the Extension Service that there are a lot of very committed professionals in the Extension Service that I think do an excellent job and perhaps across the board the Extension Service has been unfairly berated in many of these kinds of discussions.

Senator **Fowler**. Yes, Ron.

Mr. **Rivinius**. Industry people are generally more accessible to the producer than the Extension people. The business people are at your doorstep probably once a week, or if you make a call, they will be there within an hour or two if you are having some kind of a problem. Whereas, the Extension sometimes can take a week and by that time you have solved the problem.

Ms. **Hinkle**. There are many more dealers and salesmen from which to get information by the farmer, and extension agents are overworked. So the primary source of information for the farmer have been dealers and salesmen.

Senator **Fowler**. Just as a digression, how do you come up with names like Prowl and Lasso and Ambush? You do not want to voluntarily submit your marketing budget versus your R&D budget that you have been advocating, do you, Mr. Vroom? I will be glad to make that a part of the record.

Mr. **Vroom**. I cannot speak for marketing trade names. I am sorry.

Senator **Fowler**. Thank you all very, very much.

Mr. **Duskin**. I understood they threw at a dart board.

Senator **Fowler**. Our last two witnesses, Mr. Kevin Kessler, chief of the ground water management section of the Wisconsin Department of Natural Resources and Mr. Gordon Kissel, executive director of the Nebraska Association of Resources Districts.

Welcome, gentlemen, and thank you for your patience. Mr. Kessler from Wisconsin, would you like to begin, and if you can summarize your prepared testimony.

STATEMENT OF KEVIN KESSLER, CHIEF, GROUND WATER MANAGEMENT SECTION, WISCONSIN DEPARTMENT OF NATURAL RESOURCES, MADISON, WI

Mr. **Kessler**. Thank you, Mr. Chairman. I will very briefly summarize my written comments. I have enjoyed listening to the testimony this morning. I would have to say that I do agree with much of the testimony we have heard this morning.

I am representing the Wisconsin Department of Natural Resources and the Wisconsin Department of Agriculture, Trade and Consumer Protection this morning. There are about six points that I would like to summarize very briefly.

THE STATES HAVE AND SHOULD CONTINUE TO HAVE THE LEAD ROLE FOR GROUND WATER PROTECTION AND NONPOINT SOURCE POLLUTION CONTROL

First, the States presently have and we feel should continue to have the lead role for ground water protection and for protection of water quality from nonpoint source of pollution control. And that has been reflected in some of the Clean Water Act activities, and we think the Congress ought to build on that.

THE STATES ALREADY HAVE THE LEGAL AND THE INSTITUTIONAL FRAMEWORK IN PLACE TO ADDRESS MANY WATER QUALITY ISSUES

Second, the States already have the legal and the institutional framework in place to address many water quality issues, and not every State is the same in this regard. In Wisconsin we have had a priority watershed program since 1978, for example, where we provide State cost share moneys in priority watershed areas to implement best management practices for ground water and surface water protection, and our Department of Agriculture, our water quality agency and our university extension are all involved in that program. In 1984, we also passed a major comprehensive ground water legislation that has proved to be very useful in addressing this issue of agricultural chemicals in ground water. We have State ground water standards that all agencies have to meet the water quality regulatory agency, solid and hazardous waste disposal facilities as well as the Department of Agriculture for pesticides.

Senator FOWLER. Now how do you—let me just go ahead and handle this informally a little bit.

Mr. KESSLER. Sure.

Senator FOWLER. How do you describe that statute as to how tough is it and how have the farmers reacted to meeting the standards under the Wisconsin statute?

Mr. KESSLER. I think the Wisconsin statute is among the toughest and most comprehensive of the statutes in the States. It was one of the first comprehensive ground water bills and it has more detail on ground water standards than the other States.

Senator GORTON. Has it required significant changes in agricultural practices in wide areas of the State?

Mr. KESSLER. Our Department of Agriculture is developing regulations that we hope to have in place for the 1991 growing season to deal with the issue of atrazine in ground water, for example.

Senator GORTON. So, so far it has not had.

Mr. KESSLER. We have had regulations in place on a regulatory approach to deal with the problem of aldicarb in ground water since 1982. We have had major changes in our State's regulation of landfills and of agricultural chemicals and of waste water disposal facilities as a result of this comprehensive, overall legislation. And our experience has been very favorable.

Senator FOWLER. Continue, Mr. Kessler.

THE STATES ARE IMPLEMENTING IMPORTANT PROGRAMS DEALING WITH THIS ISSUE

Mr. Kessler. The third point I wanted to make is that States are already implementing various portions of programs dealing with this issue. During the past year, for example, our State conducted a statistically valid random survey of grade A dairy farm wells, and we found some rather surprising results. We sampled 534 wells. Of those, 71 contained one or more pesticide residues in detectable amounts. The most surprising part to me was that 55 of the wells, about 10 percent had high nitrates, and we had a statistical correlation between wells with high nitrates and wells that had pesticide residues which has led us to speculate that perhaps not all the problems that we are seeing are related to point sources and spills and so forth.

We are planning right now a State program where citizens and farmers can submit their own samples to the State for a State subsidized well testing program. That will cover about 2,500 wells, and we will have screening of those samples for several herbicides using a screen technique and for nitrates and then follow up sampling in more detail for any wells that show defects.

Senator Fowler. What is your estimate of cost per well to test?

Mr. Kessler. The screen technique that we are going to implement, which covers only a few herbicides that fit in the category of triazines, is going to cost us about $70. More detailed well testing can cost anywhere from a couple hundred dollars to perhaps $1,000 depending on the comprehensiveness of the testing and whether you are using commercial laboratories or State subsidized laboratories.

Another thing we have done during the past year is to coordinate our efforts between the all the agencies and develop a publication called "Nutrient and Pesticide Best Management Practices on Wisconsin Farms" which I have submitted to the committee staff for their review. That was prepared by the Department of Agriculture, my agency (the water quality agency), the university extension staff, and the Soil Conservation Service staff, cooperatively, in fact involving even some environmental groups in the preparation of that.

The thing that we recognized is that we did not want different agencies in the same State trying to deliver technical assistance to farmers and telling them different things. We felt we needed to agree on best management practices, and needed to be able to deliver the same message, and we are committed to that.

Senator Fowler. Is this—again, I thank you for indulging my interruptions—is this a role for USDA because we have, the Federal Government has the technical delivery system at least in place? Would this be, is this the role? Would you see it for it technical assistance to be delivered?

Mr. Kessler. That is one of the main concerns we have in my testimony today, Senator, is that we see the role of the USDA is in technical assistance.

Senator Fowler. Is or is not?

Mr. Kessler. Is. However, we are very concerned as State agencies that that technical assistance delivery system complement

State programs (existing State agriculture and water quality programs) and that it not compete with those existing programs. We do not want to be delivering different messages on the same issues to the same rural constituents.

Senator FOWLER. Well, how do we do that? How do we make sure that we do not? I think everybody would agree with you there. In other words, the end result is simply how do you get the management practices in place and adopted; is it not?

Mr. KESSLER. I will cover that with some of my future points. I think first of all we have to have much more research to define what the best management practices are. One of the concerns we have heard from farmers in our State as we have taken both nonregulatory and regulatory approaches is that we need to be sure what it is that we are advocating. And we need the research information to back that up to make sure it is going to work. It is, in fact, going to protect water quality. It is not just going to be theoretically an improvement, and also to be able to tell farmers what the impact is going to be in terms of their crop production.

So we need the research to back up that information. We need the agreement between the agencies as to the definition of those best management practices. We do not think that ought to be a one-way street where Federal agencies alone, particularly Federal agricultural agencies alone are defining that.

We think that definition of best management practices may vary from State to State depending on local conditions and crops and we think that it needs to be agreed upon between water quality agencies and agricultural agencies and research agencies.

Senator FOWLER. Go ahead and finish your points. And I will not interrupt you. Thank you.

FEDERAL PROGRAMS NEED TO BE BETTER COORDINATED

Mr. KESSLER. The fourth point that I was going to make is that Federal programs need to be better coordinated. We have efforts under the Clean Water Act, in section 106, to develop State ground water strategies, in section 319(i) of the Clean Water Act to develop State nonpoint source pollution programs, and under FIFRA, that the Congress has mandated and funded. We should not be ignoring those other Federal programs in our development of farm policy, and we need to do a better job at coordinating those programs. I know we have a few dedicated people in Washington that are trying to do that, but we are not seeing enough evidence of that a thousand miles from here in the Mississippi Valley.

LEGISLATION ESTABLISHING A BROAD FEDERAL FRAMEWORK ON GROUND WATER IS NEEDED

Fifth, our agencies believe that legislation establishing a broad Federal framework on ground water is needed. This issue of agricultural chemicals in ground water needs to fit in the context of ground water contamination in general. The definition of roles of State and local and Federal agencies is needed. We believe that there needs to be a Federal standards program and that numeric standards are needed to coordinate Federal programs between themselves.

We should not have a different standard used in the RCRA program, for example, for hazardous waste disposal for a pesticide and a different standard in the FIFRA program and yet another standard that is the USDA objective. We have found that our comprehensive program in Wisconsin has been very helpful in coordinating agency efforts in that regard.

USDA SHOULD RECOGNIZE THE LEAD ROLE OF THE STATES FOR GROUND WATER PROTECTION IN NONPOINT SOURCE POLLUTION CONTROL

Sixth, USDA should recognize the lead role of the States for ground water protection in nonpoint source pollution control, and I would say that we are concerned about a federally mandated program of well testing that does not recognize the role of State and local health agencies, where we already have very active programs in some States to sample private wells. People need to think about what it is, what message they are going to deliver back to the people that drink the water, about the safety of the water once they get those results, who is going to make those sorts of judgments, who the people are going to contact in terms of health agencies to ask questions and what the letters say. And so we do not want an entirely new program that ignores existing programs.

THERE ARE MAJOR AREAS WHERE WE WOULD LIKE FEDERAL ASSISTANCE

Finally, I would like to say that there are major areas where we would like Federal assistance, first in the area of research. We have a State water ground water coordinating council. We have identified, since the inception of ground water coordinating council 5 years ago, research on development of best management practices for agricultural chemicals and other research issues related to agricultural chemicals as the highest priority area for additional funding in our State. Our legislature has given us some additional money just this past biennium, but many of these issues are national issues, and the States should not have to duplicate each other in conducting this sort of research.

Second, we recognize the ability of Federal agencies in the area of technical assistance. Much more technical assistance is needed to deliver information on these best management practices as they are developed and we would welcome and encourage USDA to assist in that technical assistance delivery system.

Finally in the FIFRA programs, EPA and the States do need help in developing portions of the overall program which are regulatory in nature. In our State, we believe the issue has to be addressed by a combination of regulatory programs, development of best management practices, which means research and a technical assistance delivery system along with a monitoring program to gauge the success of your programs.

Thank you, Senator.

[The prepared statement of Mr. Kessler appears at the conclusion of the hearing.]

Senator FOWLER. Thank you very much, Mr. Kessler.

Mr. Gordon Kissel; is that correct?

Mr. KISSEL. That is correct.

Senator **Fowler**. Mr. Kissel is executive director of the Nebraska Association of Resources Districts from Lincoln. Thank you.

STATEMENT OF GORDON KISSEL, EXECUTIVE DIRECTOR, NEBRASKA ASSOCIATION OF RESOURCES DISTRICTS, LINCOLN, NE

Mr. **Kissel**. Thank you, Senator. I appreciate the invitation to come and testify today on the issue of ground water protection.

BACKGROUND

Let me give you just a quick background of the Nebraska's Natural Resources Districts. We are unique to the country in the kinds of authorities that we have. Basically, the Nebraska people believe that local government and local people can and should govern themselves.

And they also believe that that local government should be as efficient and capable as possible. In 1969, the Nebraska Legislature passed a law establishing Natural Resources Districts. In July 1972 the Districts became operational. The law consolidated over 150 different resource entities that frankly were not very efficient or very capable.

The districts are 23 multicounty, regional political subdivisions with taxing authority. They are governed by elected boards of directors. Each have professional staff hired. Some districts have a few employees. Others have as many as 40 to 50 employees. The district's budgets range from the low end of $300,000 annually to the high end being $8 million plus.

PRIORITY PROGRAMS DIFFER BASED UPON NEEDS

Districts have been asked to establish priority programs, and some of the districts within the State, you will find flood control is a major priority. Others you will find soil conservation, but frankly speaking, ground water quantity and quality has become a major priority for almost all of the 23 NRD's in Nebraska, and we see water quality becoming a higher priority by more of the districts putting more and more of their dollars in that area.

The districts are 17 years old and like many adolescents we are trying to decide what we want to be when we grow up. There have been moments of great success, and frankly there have been moments where we have had to step back and reassess our directions. We have very high expectations of ourselves and I think the State does too.

TWO EXAMPLES OF HOW I THINK LOCAL GOVERNMENTS CAN HELP IN FEDERAL PROGRAMS

Let me give you two examples of how I think local governments can help in Federal programs. I think it is important to know that local governments have to play an important role in any Federal program and frankly in Nebraska we are arrogant enough to believe that our model should be looked at.

There are two specific examples. One deals with the 1985 farm bill and the conservation provisions. And the second one deals with specific ground water management area being implemented by the

Central Platte NRD and we think it is a model that the country should look at for water quality in the 1990 farm bill.

In 1985, the conservation provisions of linking farm programs and conservation practices were important, and those conservation plans led to more farmers implementing conservation practices. In Nebraska, we have been fortunate to get a little over $5 million in ACP money. Our State Soil and Water Conservation Fund has been increased to about $4 million. That started under former Governor Kerrey's administration and has continued under the current Governor.

Local districts have responded by putting tax dollars that they have raised into a cost share money for the local farmers, and if you take the 23 districts as an aggregate, the local districts contribute about $4 million across the State so we have about $9.5 million available to us for cost share in implementing conservation provisions. This is, of course, an example of the new federalism that we have talked about. But more importantly, I think it helps the success of any Federal program.

WE HAVE TO HAVE FINANCIALLY CAPABLE LOCAL DISTRICTS TO SEE THE SUCCESS OF THIS

And the key element here is that we have to have financially capable local districts to see the success of this.

WATER QUALITY

The second example and the one that I want to talk the most about is the area of water quality. We believe that the 1990 farm bill should have strong conservation practices required in water quality area.

In Nebraska the Central Platte NRD, which is in middle part of our State, has established a ground water management area. It established restrictions on the use of nitrogen fertilizer. The program is divided into three different phrases depending on the amount nitrate found in the wells. Each phase has guidelines and requirements, requiring education, soil probe testing and water samples and in some cases it bands the use of nitrogen and the application of nitrogen at certain times of the year. It requires inhibitors at certain other times, and requires the farmers to do soil probes and water samples. Our district employees are busy collecting deep soil probes and well monitoring. They are monitoring over 500 wells out of the 4,500 irrigation wells in their district to determine levels of nitrate residue.

Studies that they have funded—frankly, they have spent about $1.5 million over the last few years in studies showing that the residue nitrates can be used and reduce the normal application of nitrates on a farmer's field. And let me just give you one quick example. If they find 100 pounds of residue nitrate in soil and water in combination, the farmer can reduce his application by that 100 pounds and come very close to sometimes exceeding the level of production that he was accustomed to. We have found that about 95 percent of the farmers have been very cooperative and have complied to those kinds of restrictions.

Most of the areas are in phase two guidelines right now which require soil probes and that sort of thing. I think the other thing that comes to play is that we believe that in just a few years—matter of fact, in maybe just a year, we will be seeing the same kind of restrictions on pesticides in that particular area.

AREAS OF RESEARCH SPECIFIC TO AGRICULTURE

Let me turn my attention now to just areas of research specific to agriculture that I think would be helpful from a local government's point of view of what would help us manage the water.

First of all, we think that development of agricultural management practices to keep pesticides and fertilizers in the root zone would be critical. I think Wisconsin has done a good job, as a matter of fact, in providing the best management practice guideline books in that area.

The second area is development of alternative chemicals that would not impair water quality.

Further research on low-input sustainable agriculture, although we do not see low-input sustainable agriculture as the panacea.

Improved techniques for pesticide cleanup.

OTHER AREAS OF TECHNICAL NEED FOR RESEARCH

Other areas of technical need for research we see the need for reliable techniques for unsaturated zone monitoring; subsurface movement of contaminants; additional risk assessment research; impacts of long-term exposure to contaminants; and new and improved techniques for detecting ground water contamination.

OTHER AREAS OF ASSISTANCE

Finally, we think that the need to ensure the accessibility of the ground water data and the analyses needs to be coordinated in a better way than you see right now—coordinate research and information to manage ground water quality through technology transfer.

The information is very sketchy when it goes through the bureaucratic maze that oftentimes research goes through, and with that, I would conclude my testimony and be happy to answer any questions.

[The prepared statement of Mr. Kissel appears at the conclusion of the hearing.]

Senator FOWLER. Thank you very much, Mr. Kissel.

Should we, we the Congress, begin our ground water initiatives with a bill that would regulate standards for farmers who are participating in farm programs?

Mr. KISSEL. I think those general guidelines would be very helpful in implementing from a local district point of view.

Senator FOWLER. I am not talking about guidelines now. I am talking about mandated standards.

Mr. KISSEL. I do not think we would have any specific problems with that if you recognized, as you heard before, the flexibility and the specific areas that could be, some sort of a range could be talked about in the best management practices used.

Senator **Fowler**. What do you think the USDA could do to better improve its educational methods for farmers in the area of water quality that would make any regulations less necessary?

Mr. **Kissel**. Two things. One, more specific research in best management practices; and second, hands-on ownership of the problem. I think in Nebraska we find a shifting of responsibilities at times that are very difficult to deal with and it leaves the farmers, I think, a little bit confused about what direction they should go.

Senator **Fowler**. That is a good point. What does the farmer need in relation to water quality research?

Mr. **Kissel**. Education and specific guidelines on how we can show cause and effect. If the district lays on a certain amount of regulation, we need to be able to prove frankly in a court of law because we have been challenged before that if we require (a) that (b) will be the result. I think that is very difficult to do in some ways, but I think we need to have a clearer direction on cause and effect. And USDA would be very helpful in providing that technical assistance to do that and the research to do that.

Senator **Fowler**. It is tough, I will tell you that.

Mr. **Kissel**. No question about that.

Senator **Fowler**. Back when I was practicing law, I represented a couple of companies and won the case where, you know, if the water is obviously polluted—I am talking about rivers now and streams and not about wells—you can always prove if you have just a reasonably good lawyer that the one contaminant, one chemical, is not harmful. But you have 200 of them in there so everybody says we did not do it so we are not responsible. They can prove that legally under your—I am not criticizing, but that is the standard of legal proof that (a) caused (b). But the result of that is that all 200 say we did not do it, and there is no public policy mechanism to say the result of 200 nonpolluting chemicals all put together in the water when you drink it, you are risking bad health.

And my State, we have 159 separate counties, and of course, agriculture is far and away the largest business, even despite Atlanta, when the water tastes funny, they do not test or are reluctant to test simply because it costs so much. That is one thing that we are looking at, of course, in this bill—$700,000, $800,000, as you said. But they, and rather than testing, they have been adjusting and reporting to me they use a little bit less fertilizer this year, and all of a sudden the water tasted better.

Mr. Kessler, you made it plain, which I appreciate, your fears about the Federal Government being involved in well testing. And I understand your line of testimony that you are worried about how this might muddle up State, the lines of authority with those States that have ongoing sampling programs.

But our goal, whether we achieve it or not, but the goal, of course, is to ensure that farm families are protected from drinking contaminated water and that our protection efforts are directed to those farms and farming areas contributing to ground water problems. Are you satisfied that your State's, Wisconsin's, sampling program is sufficient to assure this kind of protection?

Mr. **Kessler**. Absolutely not, Senator. We can use more resources, and in fact, many of the Midwest States are actively involved in well testing. Iowa—that was referred to earlier this morning——

Senator FOWLER. Right.

Mr. KESSLER [continuing]. Minnesota, both have very active programs. One of the things that I anticipate we will see out of this new program, this prototype program that we have for soliciting samples that farm families and rural families would provide and collect themselves, is a much more demand than we are able to satisfy for that sort of well testing.

Senator FOWLER. Who will pay for that?

Mr. KESSLER. That will be an issue, if we do see that demand, for our legislature and our Governor and for the State agencies. We do not have the resources if we do have a substantial more demand for that.

Senator FOWLER. Were the results that you took in your dairy farm testing, those samples, were those made public?

Mr. KESSLER. Yes, they were, and I have furnished those results and a report on those results to the committee staff. I might say the results of that sampling——

Senator FOWLER. I appreciate that. Let me just, before I forget it—is that a policy decision by the State? Was that a policy decision that well sampling should not remain confidential?

Mr. KESSLER. It is a State law. It is a State record and under our open records law, it is public information. The assembled report that I gave you does not contain names and addresses of individuals.

Senator FOWLER. No, I understand. Slade, any questions?

Senator GORTON. Mr. Kessler, what in your opinion are the differences between the traditional best management practices and the low-input sustainable agricultural practices?

Mr. KESSLER. I think the traditional best management practices were focused on a single objective. That objective may have been to prevent erosion, for example, whereas LISA BMP's should be looking more at the long term and should be looking at multiple objectives and having a broader spectrum of objectives and certainly we want——

Senator GORTON. Can you detail what is that broad spectrum? Name some, as many of those objectives as you can.

Mr. KESSLER. I am from the State water quality agency so I am not our State's LISA expert, but certainly——

Senator GORTON. But it is a broader list of objectives then the old——

Mr. KESSLER. I believe so.

Senator FOWLER. Mr. Kessler, one other thing while we get Senator Kerrey oriented here. You mentioned that again Wisconsin and Mr. Kissel made reference too, it has developed a technical guide for farmers on pesticide and nutrient, best management practices. How are you going to use these guides?

Mr. KESSLER. That technical guide is just the first step. That technical guide is on the order of 100 or 150 pages. It does not have the level of detail that we need to take to farmers and tell them what is the best management practice for a particular crop, what is the best management practice for a particular pesticide? It has some very general best management practices, the sorts of things that we can agree on based on the data that we have available right now.

Senator **Fowler**. What kind of reaction have you gotten from farmers? How enthusiastic are they about these BMP's?

Mr. **Kessler**. We have identified the needs for technical assistance and a delivery system, which we do not have an adequate system for right now. Right now this 150 page document is not something that is intended to put in the hands of every farmer. It is something to circulate among agricultural leaders, university leaders and it has an action plan for development of research priorities, technical assistance delivery systems, and educational priorities.

And we are proceeding with research on specific cropping practices and we are proceeding and have secured funding from our legislature for development of very much more specific technical assistance brochures that will go into more detail.

Senator **Fowler**. Well, let me ask you this in conclusion because your State has obviously been a leader. You have a State statute recognizing the need for this kind of information, education and conservation. And I am sure without knowing the details that part of that has been your leadership as the chief of the ground water section.

But with all that work that has already been done and State statutes in place, recognizing the sensitivity of the soil and the contamination that has resulted or you would not—we all know how difficult it is. After all is said and done, and this work has been done, and all these manuals have been developed, even if this is the first stage, is the end result, do we need to require the farmers to use these management practices?

Mr. **Kessler**. I think there is going to be a multitude of answers to that question, Senator. I think there are cases, aldicarb might be a good example, where a nonregulatory approach alone is inadequate, where we do have to have a regulatory approach to some of the problems. And I think there are many other cases where nonregulatory approaches are adequate, and I think the challenge facing us is to have the research to know what the answers are. One of the problems we had on aldicarb, for example, in the early 1980's was the manufacturer said, well, if we change the amount of application and the timing of application and the frequency of application that that will solve the problems.

And the national label was changed to say that. Our research in the last 2 or 3 years, though, has shown that alone is not solving the problem in some areas in our State, and we need to continue the regulatory approach.

Senator **Fowler**. Thank you. We welcome my colleague and learned friend from Nebraska, Mr. Robert Kerrey.

Senator **Kerrey**. Well, Mr. Chairman, I appreciate your——

Senator **Fowler**. Former Governor of his great State, and we are glad to see you.

Senator **Kerrey**. I used to harass my friend Gordon Kissel with excessive executive branch interference of his work at the local level. Mr. Chairman, I do want to start, without going overboard and ladling too much praise upon you, for your interest in ground water, but I believe it is obvious to the members of the Senate Agriculture Committee that you have taken a real interest in convincing us of the importance of developing a strategy to protect the ground water of this Nation.

One of the interesting things that I find in the Natural Resources District concept is that it focuses on the question of how we should regulate, not upon the oftentimes divisive question of whether we should regulate more or less. I have heard a number of people stand up and say that what we do not need is more regulation. And I would take issue with that, and say that the debate over more or less regulation really leads us nowhere.

The question before us is how to regulate. I think we are fortunate at this moment, not only with your leadership, but also with the presence of EPA Administrator Reilly, who participated along with Governor Bruce Babbitt of Arizona in the development of an aggressive ground water protection plan that required the resolution of many of the rather serious conflicts that exist between developmental interests and environmental interests.

Governor Babbitt resolved much of that conflict to enable the State of Arizona to put in place an extremely good ground water plan. He and Administrator Reilly in Administrator Reilly's former life developed a strategy and a proposal. And as I now understand it, EPA is going to follow on much of that work. And we are also fortunate, I think, to have Secretary Yeutter as the head of the Department of Agriculture at this moment because he worked for the Governor of Nebraska when the NRD's in Nebraska were created. He participated in their creation.

At that time in the 1960's, the principal concerns were soil loss and flood control. Now 20 years later the NRD's have followed with considerable more awareness that farming practices can endanger ground water. I see in Chuck Benbrook's presentation that he indicates what I think many of us believe as well, and that is that increasing nitrate contamination is probably the No. 1 problem that we have today with ground water. I would like to ask Mr. Kissel to comment specifically upon the NRD's capacity to implement tough Federal standards for nitrate in the ground water.

Mr. KISSEL. Well, it is certainly true in Nebraska that nitrates are the No. 1 ground water contaminant. There are probably at least six to seven areas that need some sort of regulation. Under the Nebraska statutes, as you well know, the ground water management plans, the Ground Water Management Act, and the special protection areas provide the districts some flexibility. The regulation deals with a system of education and then allowing certain banning of the application at certain times of the year to reduce the nitrate level.

The third area that I would talk about is that specifically in the Central Platte NRD where you have NRD employees going out helping the farmers do soil probes and ground water tests to determine the level of nitrate residue for their specific farm plan is the kind of role that we see ourselves taking along with education.

Senator KERREY. But you are not intimidated by the discussion of tough standards for nitrates in ground water?

Mr. KISSEL. No, I think it is important that we recognize the problem and frankly I think many of the Nebraska farmers see that as a big enough problem that they need to deal with.

Senator **Kerrey**. One of the questions that this committee will have not only to ask, but to answer, is whether or not to develop cross-compliance requirements to protect water similar to what we did with swampbuster and sodbuster in the 1985 farm bill. I find myself in agreement with the objective, but what we find, what I have found thus far is some difficulty in the achievement of the objective either because SCS is understaffed or because ARS is unable to get people in the field and work with specific practices that have been adopted to local needs.

What I am trying to center on here, Gordie, is the question of the NRD's capacity to implement a national strategy for lowering ground water contamination from nitrates.

Senator **Fowler**. Excuse me before you answer. Bob, I have got to run over, if you will conclude. Let me thank these two witnesses. We have been here about 3 hours, and it has been extraordinarily helpful I say to all concerned as we go into this. But I know, I want Senator Kerrey to conclude and take as long as you want to do so. But if you will excuse me and adjourn us at the end, I would appreciate it.

Senator **Kerrey**. I will go with you. I have asked all I need to ask.

Senator **Fowler**. Then we will let him answer. I just did not know that you might have a lot more questions. Also for the record we have a statement from Mr. Tommy Irvin, Georgia Commissioner of Agriculture. Without objection it will be included.

[The prepared statement of Mr. Irvin appears at the conclusion of the hearing.]

Mr. **Kissel**. Well, just quickly, it is a partnership between the Federal, the State and the local governments. I think in Nebraska we have very strong local governments to do the kinds of things the Federal Government wants to do. To be blunt about it, I think the weak link in Nebraska is the State agencies. We need some direction from the State agencies, and we do not have 23 NRD's going in separate directions. And I think Federal standards would help provide some of that direction to help us get the job done.

Senator **Fowler**. I thank everybody very much. We stand adjourned.

[Whereupon, at 11:50 a.m., the subcommittee adjourned, subject to the call of the Chair.]

[Material submitted for inclusion in the record follows:]

APPENDIX

STATEMENT OF CHARLES M. BENBROOK, EXECUTIVE DIRECTOR, BOARD ON AGRICULTURE, NATIONAL RESEARCH COUNCIL

Mr. Chairman, I am delighted to have an opportunity to testify today before this hearing of the Subcommittee on Conservation and Forestry. Across the nation farmers and agricultural industry leaders recognize the critical importance of reducing agriculture's contribution to water quality degradation. Indeed, there is a growing consensus--and hope--that the 1990 farm bill should address national policies governing water quality protection as thoughtfully as the 1985 farm bill addressed soil erosion control.

Nitrate contamination of groundwater is the most widespread water quality problem caused by agricultural activities. The problem arises from an excess supply of nitrogen in the rootzone relative to the needs of the crop. It is exacerbated when excessive levels of nitrogen are present in the fall, or during early spring when there is a relatively large volume of water moving downward through the soil profile. Without doubt, this problem is most serious in regions of the country where livestock production results in the need for land disposal of large volumes of manure. Because of the need to produce forages for livestock, such regions also often include legume forages in crop rotations, adding additional units of nitrogen into cropping systems. Paradoxically, many farmers who apply manure and include legumes in rotations still tend to apply fertilizer at rates comparable to their neighbors who apply no manure and grow continuous row crops.

Researchers in several states have documented farming systems that result in the soil receiving more than 100 pounds of nitrogen in excess of crop needs. Nitrate contamination of groundwater occurs as a result. The problem is not simply the manure, or the fertilizer, or the legume. It is the presence of nitrogen far in excess of the crop's needs. The solution is not to single out and punish one source of nitrogen, but rather to focus on balancing and managing the total supply of nitrogen in light of crop needs. There are a number of well-proven methods to accomplish this goal which the subcommittee should assess in crafting new water quality provisions for the 1990 farm bill. There are described in some detail in our recently released report, Alternative Agriculture.

Our report Alternative Agriculture was released September 7, 1989. It presents a comprehensive assessment of American agriculture, focusing on how alternative agriculture production systems can contribute toward improving both the economic and environmental performance of American agriculture. Water quality is a major focus of the report, as evident in excerpts from the report I include as an attachment to my testimony

As requested in your letter of invitation, I will focus this morning on findings and recommendations related to water quality. But I would like to begin by defining what we mean by alternative agriculture.

What is Alternative Agriculture?

There is no one intrinsically correct definition of alternative, sustainable, regenerative, or low-input sustainable agriculture (LISA). Some people try to ridicule or dismiss alternative agriculture and related notions as fuzzy concepts because they are difficult to define. Many concepts that have played an important role in our nation's history are difficult to define, including democracy, the nature of community, and even several provisions in the Bill of Rights. For example, what is an inalienable right?

The project committee that authored our report discussed throughout the projecthow best to define "alternative agriculture." They never really resolved among themselves how to explain the difference, or whether there really was a difference between "alternative agriculture" and "sustainable agriculture." LISA, on the other hand, clearly implies reduced input use in concert with careful attention to resource conservation. "Alternative agriculture," as defined in our report, differs from "LISA" in that alternative agriculture envisions a marked increase in reliance on some inputs (particularly genetics, labor, management, and information).

One of the most important conceptual issues the Congress needs to face in crafting the next farm bill is whether "alternative agriculture" is a process, or a distinct outcome. The answer to this question is of great importance if the Congress chooses to incorporate any new incentives for the adoption of alternative agriculture into the farm bill.

Our report defines "alternative agriculture" as a system of food or fiber production "that systematically pursues the following goals: ... nutrient cycling, ... IPM, ... better match in cropping patterns and the physical limitations of available resources...." In our definition, the distinguishing characteristic of "alternative agriculture" is the approach or strategy a farmer uses in reaching management decisions. In short, the definition stresses the goals and concepts in the farm management decision process, not a discrete specific outcome. Hence, it is going to be difficult in a static sense to apply our definition of alternative agriculture to many contemporary farming systems in reaching a judgment that the system is or is not "alternative agriculture." Moreover, it will be equally, if not more difficult to specify a discrete set of changes in farming practices and methods that will turn a "conventional" system into an "alternative" system. Notwithstanding this difficulty, many agricultural leaders and organizations are likely to advocate farm policy reforms in the 1990 farm bill designed to encourage "alternative agriculture," whatever that is, or "alternative farmers," whoever they are.

In sorting out these definitional issues, a great premium must be placed on clarity of thought and clear, precise communication. A necessary first step is to understand the differences between a farming practice, a farming method, and farming system. Once these terms are mastered, we can then proceed to begin a reasoned discussion of what a "conventional" practice, method, or system is, and how an "alternative" practice, method, or system might or should differ from a "conventional" system. The following discussion is drawn from definitions in the Glossary of Alternative Agriculture.

A farming practice is "A way of carrying out a discrete farming task such as a tillage operation, particular pesticide application technology, or single conservation practice." Most important farming operations--preparing a seedbed, controlling weeds and erosion, or maintaining soil fertility--require a combination of practices, or a method. Most farming operations can be carried out by different methods, each of which is a unique combination of different practices.

A farming method is "A systematic way to accomplish a specific farming objective by integrating a number of practices. A discrete method is needed for each essential farming task, including pre-preparing a seedbed and planting; managing irrigation; controlling pests; and preventing animal diseases.

A farming system is "The overall approach used in crop or livestock production, often derived from a farmer's goals, values, knowledge, available technologies, and economic opportunities." A farming system influences the choice of methods and practices used to produce a crop or care for animals. A farming system is a combination of methods. A farming method intended to accomplish a discrete task (maintaining soil fertility, for example) is itself a combination of discrete practices.

Successful alternative agricultural systems differ from conventional systems in that the selection of methods is tempered by consideration of opportunities to maximize positive biology and ecology-based interactions across and among the selecting of methods and practices, as well as by a desire to limit any contributions to water quality degradation. In this sense the farm management decision-process is generally more holistic, complex and interactive on alternative farms, and more one-dimensional and straightforward on conventional farms.

It is also important to stress that many conventional systems already include the same or similar methods or practices that are found on nearby alternative farms, and vice versa. Indeed, farming systems actually exist along a continuum, which might range from a conventional system characterized by monoculture, prophylactic pesticide use, and full replacement of nutrients removed by crops, to an organic system that meets the California definition of "certified organic." Along this continuum there are literally hundreds of intermediate systems.

Along this continuum, it will be difficult to reach broadly accepted judgments regarding where the line, or how the line should be drawn between conventional agriculture and alternative agriculture. It may be possible, however, to reach agreement on a set of critical practices or methods that irrevocably place a farming system on the conventional side of the spectrum (say any three of five key indicators), as well as a minimal set of practices which pushes a farming system into the "alternative" portion of the spectrum.

The Significance of Alternative Agriculture

Our report Alternative Agriculture places considerable faith in the resourcefulness of the American farmer. Moreover, the report concludes that this resourcefulness will be augmented in important ways by new knowledge that is emerging about soil biology, insect ecology, animal health promotion, and a variety of biologically-based management techniques. One member of the project committee, Dr. Richard Harwood, captured the significance of the report during the September 7th press conference by explaining that the report envisions a third major technological revolution within American agriculture in this century. The first came about as mechanical sources of power were tapped to till fields, plant, and harvest crops. Synthetic fertilizers, pesticides, and other inputs needed to fully exploit the genetic potential of hybrid crop varieties introduced in the 1950s began the second major revolution, an era of profound change based largely on major breakthroughs in chemical and energy-intensive technologies. The third major phase of evolution in agricultural technology will be rooted in biology, and its practitioners will be more reliant on careful matching of cropping systems to natural resource limitations. This era is just now underway. Think of our report as a very preliminary road map.

The transition to this new era of biologically-based farming systems will challenge both farmers and academic researchers to develop new skills and much greater sophistication in order to enlist Mother Nature as a more active partner in the enterprise of farming. Our report captured national attention by clearly stating that biologically-based farming systems can be both productive and profitable, and when more widely adopted, will offer great promise in overcoming some of American agriculture's seemingly most intractable contemporary problems, including water quality contamination.

Key Findings and Conclusions

The committee's principal conclusions relevant to groundwater quality protection, quoted from the Executive Summary of Alternative Agriculture, are:

1. "Farmers who adopt alternative farming systems often have productive and profitable operations, even though these farms usually function with relatively little help from commodity income and price support programs or extension."
2. "Well-managed alternative farming systems nearly always use less synthetic chemical pesticides, fertilizers, and antibiotics per unit of production than comparable conventional farms. Reduced use of these inputs lowers production costs and lessens agriculture's potential for adverse environmental and health effects without necessarily decreasing--and in some cases increasing--per acre crop yields and the productivity of livestock management systems."
3. "Alternative farming practices typically require more information, trained labor, time, and management skills per unit of production than conventional farming."
4. "There is inadequate scientific knowledge of economic, environmental, and social costs and thresholds for pest damage, soil erosion, water contamination, and other environmental consequences of agricultural practices. Such knowledge is needed to inform farm managers of the tradeoffs between on-farm practices and off-farm consequences."
5. "Future farm programs should offer no new incentives to manage these and other fragile lands in a way that impairs environmental quality."
6. "Surface water and groundwater quality monitoring must be more systematic and coupled with educational and regulatory policies that prevent future water contamination."
7. "Cost-effective water quality protection provisions must be incorporated into existing conservation and commodity programs."
8. "Adjustments in regional cropping patterns must be facilitated when such changes are necessary in order to make progress toward profitable and environmentally sustainable production systems."

Effects of Government Policy

The report's basic finding on the effects of government policy states:

> "Many federal policies discourage adoption of alternative practices and systems by economically penalizing those who adopt rotations, apply certain soil conservation systems, or attempt to reduce pesticide applications. Federal programs often tolerate and sometimes encourage unrealistically high yield goals, inefficient fertilizer and pesticide use, and unsustainable use of land and water. Many farmers

> in these programs manage their farms to maximize present and future program benefits, sometimes at the expense of environmental quality."

The report notes that about 70 percent of the nation's cultivated cropland have been enrolled in commodity price support programs in recent years, and that "program rules have enormous influence on agriculture." This is surely not news to members of Congress that follow developments in agricultural policy.

The report also states that over time these programs have, in some areas for certain crops, had unintended adverse impacts on the environmental--and economic--performance of farming systems. Until important reforms in the 1985 farm bill, the commodity programs generally encouraged and often handsomely awarded:

- The planting of highly erodible croplands ill-suited to cultivation, the draining of wetlands for crop production, and the establishment of irrigation systems in regions with vulnerable groundwater resources.
- Excessive application rates for certain plant nutrients--particularly nitrogen--in an attempt to boost crop yields, and hence future program payments. Without doubt, groundwater contamination with nitrates is the most serious and pressing national water quality problem stemming from agricultural production activities. The problem is always caused by application of nitrogen far in excess of crop needs. The two principal sources of excess nitrogen are fertilizer and animal manures.
- Crop specialization, rather than rotations, and separation of crops from livestock within a region, trends that generally have resulted in increased dependence on certain pesticides and biological problems in production systems (pesticide resistance, soil compaction, manure management problems).

The report repeatedly stresses one critical finding: the economic and environmental performance of farming systems are often closely interrelated. Farming systems that result in high per unit production costs often do so because of a mismatch in cropping patterns, natural resource conditions, and technology. High cost systems tend to make poor use of purchased inputs, and contribute disproportionately to pollution.

Conversely, highly efficient and profitable farming systems--those with low per unit production costs--often contribute modestly, if at all, to off-farm environmental problems. Such low cost systems benefit from a careful selection of cropping patterns, creative approaches to the management of soil nutrient and moisture levels, and the prevention of pest and animal disease losses through a sophisticated combination of genetic, cultural, and when necessary, chemical technologies. I should add that this report emphatically rejects the notion that low-cost systems are always, or necessarily low-input systems. Indeed alternative systems are typically more hi-tech, more sophisticated, and clearly more dependent on information, management, genetic, and resource conservation expenditures.

Based on these findings, the report offers a number of specific suggestions regarding how American agriculture can move ahead in meeting the multiple, interrelated challenges of improving profitability and increasing international competitiveness while also improving the environmental performance of farming systems and the safety of the food supply.

In a hearing last week before the House agriculture subcommittee responsible for pesticide legislation, several questions arose regarding the need for record-keeping by farmers to improve the ability of regulatory officials to develop more accurate estimates of exposure to pesticides through food or water. One pending piece of legislation (H. R. 3292) includes a $8 million annual authorization for the Secretary of Agriculture to conduct a biennial survey of pesticide use. Other members are considering the advisability of requiring farmers to keep and report records on pesticide use as a condition in order to qualify for participation in government farm programs. Other members have considered requiring well-testing as a condition of eligibility.

Without doubt, more information would assist state and federal officials in determining where water quality problems are most pressing, and what remedial steps might be warranted. But the generation, collection, transmission, and use of information costs money and will inevitably take time away from other activities. For farmers, complying with such requirements will not necessarily improve water quality, but will cost money and will divert management time away from other, possibly more constructive activities, such as monitoring soil nitrogen levels or pest pressures.

Accordingly, the subcommittee should carefully assess the most cost-efficient way to generate needed new information. Based on experience gained through government efforts to deal with many other major environmental challenges, it will be important to:

- Target the effort to areas where the problem warrants an increased investment of analytical resources; do not impose new requirements on regions which will not benefit from them.
- Utilize statistically designed sampling methods to develop meaningful results with a minimal investment. Generally, a properly designed 2 percent sample of wells in a region will provide sufficiently accurate data to make judgments about water quality within a given watershed, or even a county.
- Track water quality over time so that the direction and magnitude of change in conditions is known. This information is critical in targeting remedial efforts.
- Focus regional and local monitoring efforts on those contaminants most likely to be a problem in the area.
- Identify and exploit opportunities to prevent contamination as a first order of priority.

In the case of nitrate contamination, efforts could be targeted, for example, to areas in which an estimated 20 percent or more of rural wells contain nitrates at or above 50 percent of the current EPA health advisory level. Similar criteria could be defined for a series of increasingly aggressive program interventions, much like the approach now used in parts of Nebraska in dealing with nitrate contamination. A comparable strategy could be developed in addressing pesticides.

I would be glad to answer any questions you might have on specific findings or recommendations. Thank you for the opportunity to appear before you this morning.

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generating crops or products. Recently, however, this trend of specialization has slowed down. Over the past decade, many farmers have adopted alternative methods more consistent with the goals of profitability with less government support and greater natural resource and human health protection.

The following section is a brief review of the adverse consequences that some current agricultural practices have on natural resources and the environment. It must be emphasized that many conventional agricultural practices are environmentally sound and are components of certain alternative strategies. The following analyses are not intended to be fully comprehensive; however, they do illustrate the factors that must be considered in any agricultural production system.

Water Quality

Surface Water

Water pollution is probably the most damaging and widespread environmental effect of agricultural production. Agriculture is the largest nonpoint source of water pollution, which accounts for about half of all water pollution (Chesters and Schierow, 1985; Myers et al., 1985). Under sections 304(f) and 305(b) of the Clean Water Act of 1972 as amended, 17 states and Puerto Rico identified agriculture as a primary or major nonpoint source of water pollution, and 27 states and the Virgin Islands identified it as a problem (Table 2-2) (U.S. Environmental Protection Agency, 1984). Surface water damage from agriculture is estimated at between $2 billion and $16 billion per year. These estimates are approximate, however, and may underestimate the long-term costs of pollution.

Precipitation- and irrigation-induced runoff carries sediment, minerals, nutrients, and pesticides into rivers, streams, lakes, and estuaries. Most experts consider erosion's effects on water resources to be greater than its potential effects on productivity (National Research Council, 1986c; Schneider, 1986). The U.S. Department of Agriculture (USDA) calculates that the economic cost of off-farm water pollution due to agricultural erosion is from two to eight times the value of erosion's effect on productivity (U.S. Department of Agriculture, 1987a). This comparison, however, is crude.

Sediment deposition and nutrient loading are major agricultural water pollution problems (Clark et al., 1985; U.S. Department of Agriculture, 1987a). Agriculture accounts for more than 50 percent of suspended sediments from all sources discharged into surface waters (U.S. Department of Agriculture, 1987a). In predominantly agricultural regions, these percentages are higher; in other regions, agriculture's contribution is less. Nationwide trends in surface water sediment deposition between 1974 and 1981 were significantly related to cropland erosion within basins. They were not closely related to estimates of total basin erosion from forestland, pastureland, or rangeland (Smith et al., 1987).

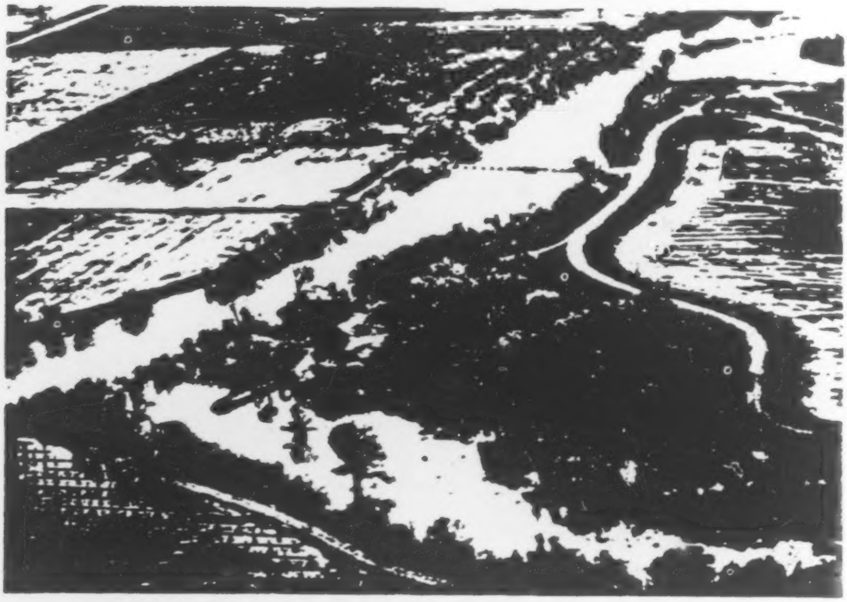
TABLE 2-2 Agriculture (Including Feedlots) as a Nonpoint Source of Water Pollution by State or Territory

Agriculture Identified as a Primary or Major Nonpoint Source of Water Pollution		Agriculture Identified as a Nonpoint Source Pollution Problem	
Delaware	Montana	Alabama	Nevada
Idaho	North Dakota	Arizona	New Jersey
Illinois	Ohio	Arkansas	New Mexico
Indiana	Oregon	California	New York
Iowa	Puerto Rico	Colorado	North Carolina
Kansas	South Dakota	Florida	Oklahoma
Kentucky	Utah	Georgia	Pennsylvania
Minnesota	Vermont	Hawaii	South Carolina
Mississippi	Washington	Louisiana	Tennessee
		Maine	Virgin Islands
		Maryland	Virginia
		Michigan	West Virginia
		Missouri	Wisconsin
		Nebraska	Wyoming

SOURCE: U.S. Environmental Protection Agency. 1984. Report to Congress: Nonpoint Source Pollution in the U.S. Office of Water Program Operations, Water Planning Division. Washington, D.C.

The principal consequence of sediment loading is increased turbidity, which causes decreased light for submerged aquatic vegetation. Species that depend on aquatic vegetation for breeding and food can thus experience stress and decline. Sediment also has direct economic consequences when it fills reservoirs, clogs navigable waterways, reduces recreational use of waters, and increases operating costs of water-treatment facilities. Between 675 million and 1 billion tons of eroded agricultural soils are deposited in waterways each year (National Research Council, 1986c; Schneider, 1986; U.S. Department of Agriculture, 1986a). The USDA (1988e) estimates that the removal from production of 30 million to 40 million acres of highly erodible land through the Conservation Reserve Program (CRP) will reduce sediment delivery to surface waters by as much as 200 million tons per year.

Phipps and Crosson (1986) and the USDA (1987a) estimate that between 50 and 70 percent of all nutrients reaching surface waters, principally nitrogen and phosphorus, originate on agricultural land in the form of fertilizer or animal waste. Nitrate, which is relatively soluble, is carried in solution by water; phosphorus is most often carried attached to sediment. From 1974 to 1981, 116 stations from the National Stream Quality Accounting Network and the National Water Quality Surveillance System reported increasing nitrate concentrations; only 27 stations reported decreases. Elevated nitrogen levels were strongly associated with agricultural activity and atmospheric deposition of nitrogen in rainfall. Phosphorus deposition has been less consistently observed because increases are closely linked to levels of suspended sediments. Nitrate moves with water; thus, nitrogen move-



Flooding and extensive water runoff carry sediment, fertilizers, and pesticides into surface water. Agriculture contributes one-half of all nonpoint surface water pollution. Flooding can also severely damage crops, land, and buildings. *Credit: Agrichemical Age.*

ment into surface waters more fully reflects the effects of agricultural activity than phosphorus movement does. Phosphorus moves as a passenger bound with sediment, much of which erodes from fields but is not deposited in surface waters (Smith et al., 1987).

Nutrient loading has had a devastating effect on many lakes, rivers, and bays throughout the country. Increased nutrient levels, particularly of phosphorus, stimulate algal growth, which can accelerate the natural process of eutrophication. In its later stages, the algal growth stimulated by nutrients will die and decay, which can significantly deplete available oxygen and reduce higher-order aquatic plant and animal populations. The accelerated eutrophication of the Chesapeake Bay is an excellent example of the consequences of nutrient loading from agricultural and municipal sources. Nutrient loading in the bay has contributed to a significant decline in the bay fisheries (Kahn and Kemp, 1985).

Sediment and nutrient runoff from agricultural land plays a part in estuary degradation. For 78 estuaries examined by the USDA, agricultural runoff supplied on average 24 percent of all nutrient loading and 40 percent of total sediment. In 22 of the 78 estuaries, agriculture contributed more than

25 percent of total nitrogen and phosphorus pollution. High rates of pesticide runoff (greater than 30 percent above the average of all coastal states) were found in 21 estuary systems. High nutrient *and* pesticide runoffs were found in 15 systems (U.S. Department of Agriculture, 1988b).

Between 450 million and 500 million pounds of pesticides are applied to row crops each year. The majority of these are herbicides, most of which are applied before planting, and many of which are incorporated into the soil. Probably less than 5 percent of all pesticides applied reach a body of water (Phipps and Crosson, 1986). The highest concentrations of pesticides are related to agricultural runoff into streams and lakes. In intensively farmed states, such as Iowa, Minnesota, and Ohio, a number of the widely used corn and soybean herbicides have been detected in rivers, many of which serve as drinking water sources. In humid areas where groundwater contributes a major proportion of stream flow, some herbicides may be delivered to surface water via groundwater (Hallberg, 1987).

It appears that many of these herbicides are not effectively removed from drinking water by conventional treatment or more sophisticated carbon filtration systems (Table 2-3). Maximum and mean levels of 10 herbicides detected in treated drinking water in Ohio and Iowa are shown in Table 2-4. In Iowa, 27 of the 33 public water supplies from surface water sources tested, or 82 percent, had 2 or more pesticides detected in treated drinking water samples; 73 percent had 3 or more; 58 percent had 4 or more; and 21 percent had 5 or more (Table 2-5). These samples were collected after rainfall between mid-April and July 30, 1986, when most herbicides are applied; consequently, they may represent a peak of exposure to those compounds. The mean detection levels were below 4.0 parts per billion (ppb). Samples collected and analyzed by Monsanto between May 1985 and March 1986, however, had only slightly lower percentages of detection for all herbicides except alachlor, which was far lower, in treated drinking water from surface water sources (Wnuk et al., 1987).

Glenn and Angle (1987) studied the effect of tillage systems on runoff of the herbicides atrazine and simazine in the Chesapeake Bay watershed. There was less runoff of water, atrazine, and simazine from the untilled fields compared to conventionally tilled fields each year that a major rain occurred during the growing season. From 1979 through 1982, total runoff from fields in the untilled watershed was 27 percent less than that from the conventionally tilled watershed. The highest levels of atrazine in runoff water were 1.332 micrograms/liter and 0.975 micrograms/liter in conventional tillage and no-tillage systems, respectively, or 1.6 and 1.1 percent of atrazine applied at 2 pounds/acre. The highest reported runoff of simazine at 2 pounds/acre was 0.456 micrograms/liter or 0.5 percent for conventional tillage and 0.210 micrograms/liter or 0.36 percent of the total applied for no tillage. Most of the runoff occurred within 2 weeks of application. In 1981 and 1982, when rainfall was delayed more than 2 weeks, levels declined substantially. Losses of up to 16 percent for atrazine and up to 3.5 percent for simazine have been reported (Glenn and Angle, 1987).

TABLE 2-3 Pesticide Detections Reported in Iowa Drinking Water Survey (in percent)

Water Type	Atrazine	Cyanazine	Metolachlor	Alachlor	Metribuzin	Trifluralin	Butylate	Carbofuran	2,4-D	Dicamba
Treated water	30/33 (91)	26/33 (79)	21/33 (64)	17/33 (52)	4/33 (12)	1/33 (3)	1/33 (3)	9/33 (27)	2/30 (7)	1/30 (3)
Untreated water	14/15 (93)	11/15 (73)	11/15 (73)	10/15 (67)	1/15 (7)	0/15 (0)	0/15 (0)	5/15 (33)	2/14 (14)	1/14 (7)
Total	44/48 (92)	37/48 (77)	32/48 (67)	27/48 (56)	5/48 (10)	1/48 (2)	1/48 (2)	14/48 (29)	4/44 (9)	2/44 (5)

NOTE: Values indicate number of positive detections/number of samples analyzed (percent).

For mean levels detected, see Table 2-4. Means for all compounds were below 4.0 µg/l. Samples were taken in the spring when the presence of compounds in water may have been highest as a result of agricultural runoff.

SOURCE: Wnuk, M., R. Kelley, G. Breuer, and L. Johnson. 1987. Pesticides in Water Supplies Using Surface Water Sources. Iowa City, Iowa: Iowa Department of Natural Resources and University Hygienic Laboratory.

TABLE 2-4 Pesticide Concentrations From Finished (Treated) Public Drinking Water Supplies Derived From Surface Waters (in micrograms/liter)

	Maximum Reported			
Pesticide	Ohio	Iowa	Mean in Iowa	Residues Detected, Iowa City, Iowa, May 18–19, 1986
Herbicides				
Alachlor	14.3	8.8	1.1	8.8
Atrazine	30.0	24.0	3.8	15.0
Butylate	—	0.3	0.27	—
Cyanazine	2.4	17.0	2.7	7.2
2,4-D	—	0.2	0.23	0.2
Dicamba	—	1.4	1.4[a]	—
Linuron	0.6	—	—	—
Metolachlor	24.2	21.0	2.9	10.0
Metribuzin	—	0.3	0.29	0.3
Simazine	1.0	—	—	—
Trifluralin	—	0.1	0.13[a]	—
Insecticide				
Carbofuran	—	14.0	—	6.0

NOTE: Maximum levels reported from studies in Ohio (D. Baker, 1985) and Iowa (M. Wnuk et al., 1987), and multiple residues in Iowa City, Iowa, tap water May 18–19, 1986.

[a] Only one detection (see Table 2-3).

SOURCES: Baker, D. B. 1985. Regional water quality impacts of intensive row-crop agriculture: Lake Erie Basin case study. Journal of Soil and Water Conservation 40(1):125–132; Hallberg, G. R. 1987. Agricultural chemicals in ground water: Extent and implications. American Journal of Alternative Agriculture 2(1):3–15; Kelley, R. D. 1987. Pesticides in Iowa's drinking water. Pp. 115–135 in Pesticides and Groundwater: A Health Concern for the Midwest. Navarre, Minn.: The Freshwater Foundation and U.S. Environmental Protection Agency; Wnuk, M., R. Kelley, G. Breuer, and L. Johnson. 1987. Pesticides in Water Supplies Using Surface Water Sources. Iowa City, Iowa: Iowa Department of Natural Resources and University Hygienic Laboratory.

The USDA predicts that pesticide and fertilizer use may be reduced by 61 million pounds and 1.4 million tons, respectively, from 1985 levels as a result of land idled under the CRP. Because idled land is highly erodible, the reduction in fertilizers and pesticides reaching surface water through runoff may be proportionally greater as a percentage of total pesticides and fertilizers applied (U.S. Department of Agriculture, 1988e).

Declining but detectable levels of many chlorinated hydrocarbon pesticides are still found in several fish, shellfish, and bird species and waterborne sediments, particularly in the Great Lakes (Hileman, 1988). Levels of dichloro diphenyl trichloroethane (DDT) in fish contributed to a dramatic decline in predatory bird populations, such as the peregrine falcon, osprey, and bald eagle in the 1960s and 1970s. The use of most persistent organochlorine pesticides has been phased out in the United States, although they continue to enter the environment as inert ingredients in a few currently used pesticides, and through their continued use worldwide. Some of these compounds are carried through the atmosphere and deposited far from

TABLE 2-5 Number of Pesticides Detected in Treated Drinking Water Samples in Iowa

Number of Individual Pesticides Detected in Treated Water Samples	Number of Supplies with the Number of Pesticides Listed in Column 1	Population (number) Served by These Supplies	Percentage of Water Supplies in the Study Containing an Equal or Greater Number of Pesticide Residues Listed in Column 1
1	3	136,725	91
2	3	2,828	82
3	5	33,222	73
4	12	115,485	58
5	3	239,386	21
6	3	15,874	9
7	1	20,000	3

SOURCE: Wnuk, M., R. Kelley, G. Breuer, and L. Johnson. 1987. Pesticides in Water Supplies Using Surface Water Sources. Iowa City, Iowa: Iowa Department of Natural Resources and University Hygienic Laboratory.

their point of application. The presence of toxaphene, chlordane, and other chlorinated hydrocarbon compounds in the Great Lakes is an example of this phenomenon (Hileman, 1988). The U.S. Environmental Protection Agency (EPA) (1987) reports that other pesticides, notably the herbicide alachlor, have been detected at up to 6.59 ppb in rainwater.

Mineralization and salinization of soils and irrigation wastewater are growing problems in irrigated agriculture, primarily in the West. Soil salinization and mineralization reduce crop yields, and, if not corrected, will ultimately leave the land unfit for agricultural purposes. The adverse reproductive effect of selenium on waterfowl in the Kesterson wildlife refuge in California is the most publicized example of the nonagricultural effects of salinization. The salinization and depletion of the Colorado River from its use as agricultural irrigation water throughout its course is perhaps the most vivid example of agriculture's effect on water quality and quantity in the West.

Amendments to the Clean Water Act in 1987 require states to report their principal nonpoint sources of water pollution and programs in place to mitigate the problem. The act does not require implementation of measures to reduce nonpoint source pollution of surface waters, however. In 1988, the USDA's National Program for Soil and Water Conservation and the Rural Clean Water Program conducted 22 water quality improvement projects around the nation. Other provisions of the Food Security Act of 1985, such as the CRP and conservation compliance, will also help reduce agricultural nonpoint surface water pollution. Incentives integrated into agricultural conservation and commodity programs will likely remain the most effective way to reduce surface water pollution from agricultural sources, in lieu of further amendments to the Clean Water Act or regulations promulgated under the act.

Groundwater

Groundwater is the source of public drinking water for nearly 75 million people. Private water wells supply water to an additional 30 million individuals. Nearly 50 percent of all drinking water, 97 percent of all rural drinking water, 55 percent of livestock water, and more than 40 percent of all irrigation water is from underground sources. Accumulating evidence indicates that a growing number of contaminants from agricultural production are now found in underground water supplies (National Research Council, 1986b; U.S. Department of Agriculture, 1987b, 1987d).

Increased use of nitrogen fertilizers and pesticides, particularly herbicides, over the past 40 years has raised the potential for groundwater contamination. Greater use of feedlots that concentrate manure production also heightens this risk. Several of the most widely used pesticides have the potential to leach into groundwater as a result of normal agricultural use. The EPA has initiated a nationwide survey of pesticides in groundwater with results anticipated in 1990. The high-priority pesticides in that survey are listed in Table 2-6 (U.S. Department of Agriculture, 1987d).

Pesticides have been detected in the groundwater of 26 states as a result of normal agricultural practices (Williams et al., 1988). The most commonly detected compounds are the herbicide atrazine and the insecticide aldicarb. Aldicarb, the most acutely toxic pesticide registered by the EPA (LD_{50}*, 0.9 milligrams/kilogram), has been found in 16 states; in many states, however, detections are isolated. Atrazine, the second most used herbicide in the nation, has been found in the groundwater of at least 5 states, usually at levels between 0.3 and 3.0 micrograms/liter. Tests show that atrazine is oncogenic in laboratory rats. The EPA is currently reviewing these studies but has not yet classified atrazine as an oncogen. The herbicide alachlor, recently banned in Canada and classified by the EPA as a probable human carcinogen, is the next most commonly detected pesticide in groundwater. It has been found in 12 states at a median concentration of 0.90 micrograms/liter. Pesticides detected in groundwater as a result of agricultural use in 26 states are listed in Table 2-7. Pesticides detected in groundwater used for drinking water in Iowa and Minnesota are listed in Table 2-8.

A survey by the U.S. Geological Survey (USGS) of 1,663 counties showed 474 counties in which 25 percent of the wells tested had nitrate-nitrogen (NO_3N) levels in excess of 3 milligrams/liter (Figure 2-8). Levels above 3 milligrams/liter are considered elevated by human activities, primarily nitrogen fertilizer use (Nielsen and Lee, 1987). In 87 of the 474 counties, at least 25 percent of the sampled wells exceeded the EPA's 10 milligrams/liter interim standard for nitrate in drinking water. Prolonged exposure to levels exceeding this standard can lead to methemoglobinemia (oxygen deficit in the blood), although reported instances of this condition have been rare. The USDA (1987d) predicted that wells in an additional 149 counties may

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*LD_{50}, or the Lethal Dose 50, is the dose of a substance that kills 50 percent of the test animals exposed to it. The lethal dose can be measured orally or dermally.

TABLE 2-6 Priority Pesticides in EPA's National Survey of Pesticides in Groundwater (in thousands of pounds)

Pesticide	Type[a]	Estimated Use[b]	EPA Description
Acifluorfen	H	1,399	Leacher
Alachlor	H	85,015	Leacher
Aldicarb	I, N	2,271	Mobile; marginal persistence
Ametryn	H	96	Leacher
Atrazine	H	77,316	Leacher
Bentazon	H	8,410	Leacher; toxicological concern
Bromacil	H	1,234	Leacher
Butylate	H	55,095	Mobile; uncertain persistence; toxicological concern
Carbofuran	I, A, N	7,695	Leacher
Chloramben	H	6,069	Leacher
Chlordane	I	11	Persistent; possible direct contamination via termiticide use
Cyanazine	H	21,626	Leacher
Cycloate	H	52	Mobile; uncertain persistence; toxicological concern
2,4-D	H	37,217	Marginal leacher; heavy use
Dalapon	H	261	Leacher
DCPA	H	196	Leacher
Dicamba	H	4,158	Leacher
Dinoseb	H	8,835	Leacher
Diphenamid	H	698	Marginal leacher; toxicological data gaps
Disulfoton	I, A	2,105	Leacher
Diuron	H	1,861	Leacher
Fenamiphos	I, N	348	Moderate leacher; toxicological concern
Fluometuron	H	2,943	Leacher
Hexazinone	H	11	Leacher
Maleic hydrazide	H	287	Leacher; toxicological data gaps
MCPA	H	9,861	Marginal leacher
Methomyl	I	425	Leacher
Metolachlor	H	37,940	Leacher
Metribuzin	H	10,603	Leacher
Oxamyl	I, A, N	51	Leacher
Picloram	H	549	Leacher
Pronamide	H	83	Leacher
Propazine	H	1,287	Leacher
Propham	H	445	Leacher
Simazine	H	3,975	Leacher
2,4,5-T	H	204	Marginal leacher
2,4,5-TP	H	7	Marginal leacher
Terbacil	H	833	Leacher

[a] Abbreviations: A = acaricide; H = herbicide; I = insecticide; N = nematicide.
[b] Thousands of pounds of active ingredient per year used for agricultural purposes only.

SOURCE: U.S. Department of Agriculture. 1987. The Magnitude and Costs of Groundwater Contamination From Agricultural Chemicals—A National Perspective. Staff Report AGES870318. Economic Research Service. Washington, D.C.

TABLE 2-7 Confirmed Pesticide Detections in Groundwater Due to Normal Agricultural Use

Pesticide	Health Advisory Level[a] (parts per billion)	States	Median Concentration[b] (parts per billion)
Alachlor	1.5[c]	CT, FL, IL, IA, KS, LA, MA, ME, NE, PA, WI	0.90
Aldicarb	10	CA, FL, MA, NC, NY, RI, WI	9.00
Aldrin		MS, SC	0.10
Arsenic		TX	N/A
Atraton		MD	0.10
Atrazine	3.0	CA, CO, CT, IL, IA, KS, MD, ME, NE, NJ, PA, VT, WI	0.50
BHC		MS	2.70
Bromacil	80	CA, FL	9.00
Carbofuran	36	MA, NY, RI	5.30
Chlordane	0.03[c]	MS	1.70
Chlorothalonil	1.5[c]	ME, NY	0.02
Cyanazine	9.0	IA, LA, MD, NE, PA, VT	0.40
1,2-D	0.0013[c]	CA, CT, MA, NY	4.50
1,3-D	0.20[c]	NY	123.00
2,4-D	70	CT, MS	1.40
DCPA	3,500	NY	109.00
DDT		MS, NJ, SC	1.70
Diazinon	0.63	MS	162.00
Dibromochloropropane	0.02[c]	AZ, CA	0.01
Dicamba	9.0	CT, ME	0.60
Dieldrin	0.00219[c]	NE, NJ	0.02
Dinoseb	7.0	MA, ME, NY	0.70
Diuron	14	CA	N/A
Endosulfan		ME	0.30
Ethoprop		NY	N/A
Ethylene dibromide	0.0005[c]	CA, CT, GA, MA, NY, WA	0.90
Fonofos	14	IA, NE	0.10

(Table 2-7 continued on page 108)

have contaminated water based on high susceptibility to contamination and fertilizer use (Figure 2-9) (Nielsen and Lee, 1987).

The USDA calculates that 1,437 counties, or 46 percent of all U.S. counties, contain groundwater susceptible to contamination from agricultural pesticides or fertilizers (Figure 2-10). An estimated 54 million people living in these counties rely on underground sources of drinking water. The costs or benefits of decontaminating this water are not currently quantifiable. It is likely, however, that contamination in certain regions will persist for many years after remedial actions are taken (Nielsen and Lee, 1987). Several states (including California, Florida, Iowa, New York, and Wisconsin) have developed strategies for dealing with agriculturally induced groundwater contamination. But changes in agricultural practices to reduce groundwater contamination are not widespread. The EPA is also developing a national

TABLE 2-7 *(Continued)*

Pesticide	Health Advisory Level[a] (parts per billion)	States	Median Concentration[b] (parts per billion)
Hexazinone	210	ME	8.00
Lindane	0.026[c]	MS, NJ, SC	0.10
Linuron		WI	1.90
Malathion		MS	41.50
Methamidophos		ME	4.80
Methomyl	175	NY	N/A
Methyl parathion	2.0	MS	88.40
Metolachlor	10	CT, IL, IA, PA, WI	0.40
Metribuzin	175	IL, IA, KS, WI	0.60
Oxamyl	175	MA, NY, RI	4.30
Parathion		ND	0.03
Picloram	490	ME, ND, WI	1.40
Prometon	100	TX	16.60
Propazine	14	NE, PA	0.20
Simazine	35	CA, CT, MD, NE, NJ, PA, VT	0.30
Sulprofos		IA	1.40
TDE	0.031	MS	4.80
Toxaphene		MS	3,205.00
Trifluralin	2.0	KS, MD, MS, NE	0.40

[a] The EPA sets the Proposed Lifetime Health Advisory Level. The EPA has not set levels for all pesticides.

[b] Median of the concentration of positive detections for all confirmed studies. If multiple studies were not done on a particular chemical, the single study average is given. If the data base reports a single positive well, then the average concentration reported for that well is given.

[c] For carcinogens, the Proposed Lifetime Health Advisory Level is based on the exposure levels that present a 1 in a million risk of cancer in the exposed population.

SOURCE: Williams, W. M., P. W. Holden, D. W. Parsons, and M. N. Lorber. 1988. Pesticides in Ground Water Data Base: 1988 Interim Report. Office of Pesticide Programs. U.S. Environmental Protection Agency. Washington, D.C.

groundwater protection strategy. Once the EPA's ongoing survey of pesticides in groundwater is complete, additional time will be needed to carry out detailed risk-benefit assessments required by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). The committee notes that opportunities exist today to reduce surface water and groundwater contamination from agricultural chemicals through modified agricultural practices. Some of the modifications include increased use of legumes as a nitrogen source, adoption of integrated pest management (IPM), or shifts in regional cropping patterns.

The Effects of Irrigation

Irrigated agricultural acreage doubled from 25 million acres in 1949 to slightly more than 50 million acres in 1978. Since then, total irrigated acre-

TABLE 2-8 Pesticides Detected in Underground Drinking Water Supplies in Iowa and Minnesota

Common Name of Active Ingredient	Maximum Concentration (micrograms/liter) in Iowa and Minnesota[a]	Mean Concentration (micrograms/liter) in Iowa and Minnesota	Percentage of Detections in Iowa and Minnesota[a]
Herbicides			
Alachlor	16.6/9.8	0.5	15/11
Atrazine	21.1/42.4	0.2	72/72
Chloramben	1.7/N.D.	—	< 1/0
Cyanazine	13.0/0.10	0.5	12/1
2,4-D	0.2/4.2	0.2	< 1/2
Dicamba	2.3/2.1	0.3	2/2
Metolachlor	12.2/2.1	0.5	10/2
Metribuzin	6.8/0.78	0.5	9/2
Picloram	N.D./0.13	—	0/1
Propachlor	1.7/0.52	0.3	1/3
Simazine	N.D./2.6	—	0/ < 1
2,4,5-TP	N.D./0.26	—	0/1
Trifluralin	0.2/N.D.	—	1/0
Insecticides (and nematicides)			
Aldicarb	N.D./30.6	—	0/ < 1
Carbofuran	0.06/N.D.	—	2/0
Chlorpyrifos	0.07/0.21	0.1	< 1/2
Fonofos	0.90/N.D.	0.2	1/0
Phorate	0.10/N.D.	—	< 1/0

NOTE: N.D. means not detected. A dash indicates insufficient data to calculate mean.

[a] The two numbers listed for each active ingredient apply to Iowa and Minnesota, respectively.

SOURCE: Hallberg, G. R. 1987. Agricultural chemicals in ground water: Extent and implications. American Journal of Alternative Agriculture 2(1):3–15.

age in production has declined to about 45 million acres (U.S. Department of Agriculture, 1986a). The growth of irrigation has been most dramatic in the western Great Plains. There, irrigation has increased the production of corn and sorghum, thus contributing to the growth of cattle feedlot operations nearby. As large quantities of water are used for irrigation, however, some water tables decline and the cost of irrigation can rise. Inefficient irrigation practices have contributed to aquifer depletion in some regions. On sandy soils, certain irrigation practices have contributed to the movement of pesticides and nitrate into groundwater.

Irrigation has made agriculture possible in areas previously unsuitable for intensive crop production, such as the sandhills of Nebraska, parts of the central valley of California, and much of the arid West. In certain regions of California, irrigation is depleting aquifers at rates up to 1.5 million acre-feet per year. Land subsidence of up to 10 feet has resulted in some areas

National Association
of State Universities
and Land-Grant Colleges

Statement by

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Before the Subcommittee on Conservation and Forestry
of the Committee on Agriculture, Nutrition and Forestry
U.S. Senate

October 24, 1989

Mr. Chairman, members of the subcommittee, I appreciate this opportunity to appear before you to speak on the subject of water quality. I serve as the Director of the Water Quality Initiative at the National Association of State Universities and Land-Grant Colleges (NASULGC). The membership of this association is comprised of 149 major U.S. public research universities, including all U.S. Land Grant institutions. Within NASULGC, the Experiment Station Committee on Organization and Policy (ESCOP) serves as the representative governing body of the State Agricultural Experiment Stations, and the Extension Committee on Organization and Policy (ECOP) serves as the governing body representing the State Cooperative Extension Services.

Both committees, ESCOP and ECOP, represent institutions that have joint partnerships with local, State, and Federal governments. Federal funding to the State Experiment Stations is directed through the Department of Agriculture's Cooperative State Research Service (CSRS). Federal funding for the State Cooperative Extension System is provided through the Department's Extension Service (ES). The State Experiment Stations and the State Extension Service both work to cooperate and coordinate with their Federal partners at the Department of Agriculture. However, when considering water quality research and Extension efforts, it is important to understand that the States and local governments often provide 2 to 3 times the amount of funding that is available from the federal government.

ESCOP and ECOP have been working cooperatively for a number of years to develop an awareness of the need to protect our nations's groundwater. In 1985 the two committees jointly published a report entitled Groundwater Quality and Management: Research and Extension, from which I quote:

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> Few doubt that contamination of groundwater is a growing problem. The impact of agriculture on water quality and quantity is an issue of major national importance. Proper management of agricultural systems to maintain acceptable groundwater quality is increasing in importance. Research efforts need to be focused on physical, chemical and biological processes that influence groundwater quality...There is an immediate need for increased research on source and prevention, fate, remedial, impact and institutional issues.
>
> ...Technology transfer through Cooperative Extension is proposed to transmit benefits of research investment to the public. Issues of training and numbers of personnel are key constraints to Extension's programming in groundwater quality.

Since the time this report was issued, the general public has grown increasingly alarmed concerning the purity and safety of ground and surface waters. Congress has reflected this concern through a number of hearings and the consideration of a number of groundwater protection bills. Various Federal agencies have developed water quality protection programs. The President introduced a "Water Quality Initiative" in his budget proposal for fiscal year 1990. Numerous reports have come out, including a study by the Interagency Task Force on Groundwater on behalf of the Office of Management and Budget (OMB) entitled A Description on Major Federal Scientific and Technical Ground-Water Programs: Fiscal Year 1987; and a report entitled Federal Ground-Water Science and Technology Programs: The Role of Science and Technology in the Management of the Nation's Ground-Water Resources, conducted by the Subcommittee on Ground Water, Committee on Earth Sciences, of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). The reports for OMB and FCCSET focused largely on identifying how much money was being spent in each of the agencies to address specific water quality topics.

Despite the many good efforts that are underway, we are gathered here today because there is still the fear that not enough is being done to protect our nation's invaluable water resources. Sadly, many of the research and education needs identified in the 1985 report are still "needs" today. Many good programs are being conducted by the research and Extension communities to protect water quality, but not enough is being done. We want to do more.

I. RESEARCH

A. Recent and Ongoing Activities

A study was conducted to determine the amount of money and personnel devoted to water quality at the State Agricultural Experiment Stations, a summary of which is included in the attachments. A search for water quality projects was conducted on the computerized Current Research Information System (CRIS). Each potentially relevant project identified in the search was then individually reviewed and assigned, if appropriate, to one of ten classification categories:

Surface Water

1. Pesticides, organic compounds, and heavy metals;
2. Nutrient and waste materials;
3. Water management;

Groundwater

4. Pesticides, organic compounds, and metals.
5. Nutrients and wastes.
6. Recharge, irrigation, and precipitation.

General

7. Soil and crop management.
8. Impact on biological systems.
9. Geologic background.

Relevant but Indirect

10. Indirect water quality research.

The projects commonly were relevant to several categories and judgment had to be used in determining the percent of total project effort to be assigned to individual categories. The last category of "Relevant but Indirect" was not included in the calculations of dollars and personnel assigned to water quality protection.

Aggregating for the nation as a whole, fiscal year 1987, $16.3 million dollars were spent through the Cooperative State Research Service. These funds were allocated over some 818 projects that included water quality components. State and other non-federal funds amounted to $85.7 million, allocated over some 4,305 projects. Studies of fiscal years 1988 and 1989 are still underway; however, estimates on funding available through CSRS in fiscal years 1988, 1989 and anticipated funding in 1990 are provided in Figure 1.

New allocations for university research on the relations of agricultural production to water quality protection became available in the FY 1989 budget: of the $3 million appropriated for water quality through the Cooperative State Research Service, approximately $1.2 million was directed funding, leaving approximately $1.8 million nationally for new research projects. The money was divided evenly between the four research regions of the country: northeast, north central, south and west (a diagram of the State Agricultural Experiment Stations research regions is included in the attachments). Leading scientists within each region met to identify and prioritize water quality research issues within their regions. Some 238 research proposals were submitted, of which 23 were funded. Descriptions of the projects that received funding are included in the attachments. I am told that over one hundred of the proposed studies were of sufficient quality to have received funding, had funds been available.

B. Needs

Water quality research is very expensive. Groundwater protection research is especially expensive. Let me provide an example. To study the movement of agricultural chemicals through the soil profile into the groundwater usually requires drilling wells for sampling, which may cost several thousand dollars apiece. To process and analyze a water sample for agricultural contaminants following EPA protocols will cost several hundred dollars. Each well site will require a number of samples to follow fluctuation and movement of the chemicals over time. To get a rough feeling for the costs, let us suppose that one sample is taken from one well every two weeks over the course of a year. Analyzing these samples will cost over $7,000 to $8,000. Imagine that 10 sampling sites are chosen (which is a very small number), then $70,000 to $80,000 a year will would be spent on sampling costs alone, not to mention $20,000 to $30,000 in drilling costs, and additional funds for labor and other costs. This example portrays the costs of one fairly small study.

The States have cooperated with the Department of Agriculture in development of the Water Quality Program Plan to Support the President's Water Quality Initiative, a copy is included in the attachments. In this plan, the following research priorities have been identified:

* developing improved methods for sampling, measuring, and evaluating groundwater contamination problems;

* conducting fundamental research to provide new technology for improved management of chemicals used in agriculture; and

* improved agricultural chemical and production management systems.

An extensive list of specific research area needs is provided in the report Groundwater Quality and Management: Research and Extension.

II. DATA COLLECTION

In a National Research Council study, Pesticides and Groundwater Quality, it is stated that

> Some 200 pesticides are in common use, and a wide range of hydrogeologic conditions affect the susceptibility of groundwaters to contamination. Clearly it is impracticable to sample every aquifer and test for every pesticide. Rather, efficient monitoring of resources depends on the establishment of systematic procedures for sampling and testing and the collection of data that can be used to identify critical site/pesticide combinations.

A tremendous amount of groundwater data is being collected by the Environmental Protection Agency, the Department of Agriculture and the United States Geological Survey, not to mention the data being collected in the States. Unfortunately, the many data bases that have been created are rarely compatible and little agreement exists on a standard set of measurements to be incorporated in all studies, despite a report by EPA that suggests the need to establish agreed upon measurements and protocols. Initial efforts are underway, but little has been implemented at this time. This is regrettable, because this confusion will greatly reduce our ability to compare the results of one study with another, which greatly reduces the utility of all of our programs.

III. EDUCATION

One of the key issues being debated is the relation between research and Extension. Some argue that we need to wait for 10 years to work out some of the research and technical issues befored Extension and education programs are implemented. I think that I can safely say that the Extension and education c ommunities categorically disagree with this proposal.

There is a tremendous amount of information on water quality protection that can be communicated now, and there are management practices to protect water quality that need to be implemented now. It is true that there are gaps in our research and knowledge base that desperately need to be addressed, particularly in the area of fate and transport of agricultural chemicals in the environment. As such information becomes available, it needs to be readily incorporated into ongoing education and extension efforts. However, there is no need to wait. There is more that can be done now than we can do with the limited resources that are currently available.

A. Recent and Ongoing Activities

In fiscal year 1989 approximately $1.5 million in new appropriations were made available to address water quality concerns through the Extension Service, which identified three high priority issues for the FY 1989 program:

(1) the interactions of pesticides, soils, and water quality;

(2) the interactions of nitrogen fertilizers, soils, and water quality; and

(3) the testing and treatment of rural water supplies.

Each State was invited to submit proposals to address these issues; each project could cost up to $25,000 per State, but the Federal funds had to be matched by funds from the counties or State. I can obtain a list of the projects funded in 1989, if the subcommittee is interested.

A large body of educational materials on water quality protection are being developed. Samples of such materials are included in the attachments.

The State Cooperative Extension Service (CES) cooperated with the Department of Agriculture in the development of the education and technical support provisions of the Water Quality Program Plan to Support the President's Water Quality Initiative. The following priority areas were cited.

* Expanding USDA and CES staff capabilities to deliver educational and technical assistance to producers for effective agrichemical and waste product management and environmental stewardship.

* Developing demonstration projects to —

  - demonstrate state of the art technologies and farm practices in eight sites where agricultural chemicals have been detected in soils and water which impair usage;

  - enable the Soil Conservation Service National Technical Centers and State offices to prepare agricultural and conservation practice standards, interpret soils information regarding the fate and transport of chemicals and implement computerized color mapping technology for the planning and application of water quality management practices. ES will participate with SCS in updating field Office technical guides.

B. Needs

In a report by the Extension Committee on Organization and Policy, Groundwater Education: A Challenge for the Cooperative Extension System, it was stated that "major gaps in Extension's ability to conduct groundwater education programs include the conventional problems of personnel limitations and the need for staff training."

Because of resource shortages, a number of critical program areas are not being addressed. It is widely recognized that pesticide and fertilizer dealers have a tremendous impact on farmer's decisions regarding chemical application rates, yet there is no national program to certify, train or provideeducational materials to the dealers. Compounding this, no national program exists to provide application recommendations for reduced input management systems. Current pesticide education programs focus on restricted use pesticides, no national program addresses general purpose pesticides, which make up the bulk of the farm and garden use of agricultural chemicals. While some individual States have vigorous water well testing programs, resources have not been available for a national campaign to educate farmers and rural residents regarding the importance of water well testing. With a declining contribution by the Federal government to Extension programs over the past decade, States have had to struggle to make up the difference when they could.

It is not that we are unwilling to do more, we simply do not have the financial or the personnel resources to do all of the things we know need to be done.

IV. TECHNICAL ASSISTANCE

The Soil Conservation Service (SCS) within the Department of Agriculture has the defined role of providing technical assistance to farmers. In the past, SCS was primarily involved in providing technical assistance for preventing soil erosion; they assisted farmers in establishing terraces or implementing other appropriate practices. In the last several years there has been an expansion of interest and efforts by SCS in the area of water quality protection. Federal and State Extension Service personnel are working with SCS to incorporate water quality issues into the SCS technical field guides, so that water quality protection techniques are identified and available for delivery to farmers.

As pointed out by Ken Cook of the Policy Center for Resource Economics, at a conference on "Agriculture and Water Quality" held by the National Governors Association:

> Soil erosion is a problem that was fairly well understood from a physical standpoint and an environmental standpoint, thanks to work done by the U.S. Soil Conservation Service in developing a nationwide inventory. We also understood soil conservation from an institutional viewpoint, because we knew how well existing programs were working to deal with the problem and how they were not working.

Unfortunately, this same kind of information is not yet available for agricultural chemicals. It is not yet possible so assign a "groundwater infiltration and risk index" to each agricultural chemical, so that appropriate management options can be selected and implemented. Indeed, contrary to the intent and provisions of the Safe Drinking Water Act, national drinking water standards for allowable levels of contaminants have not been set for many agricultural chemicals.

Because of basic gaps in our understanding of how a number of agricultural chemicals move through the environment, it will be difficult to develop "cook-book" protocols for preventing groundwater contamination by agricultural chemicals. A closer working relationship with the universities will have to be forged, as new technologies and management strategies are tried and tested.

Reducing soil erosion can also reduce surface water contamination, since agricultural chemicals can be bound to soil particles as they are carried into streams and lakes. Unfortunately, technologies that reduce soil erosion may also contribute to increased groundwater contamination as increased water infiltration may facilitate movement of agricultural chemicals through the soil profile into groundwater. Some technologies to prevent soil erosion will have to be reexamined to consider their impact on groundwater quality. Moreover, decision-tools will have to be created to balance the relative hazards from soil erosion against the risks of groundwater contamination, when practices to address one problem exacerbate the other. Such decision-making tools will have to be based on site-specific environmental parameters, since these factors (soil texture, precipitation patterns, depth of the groundwater aquifer, etc.) will determine how to combine management practices to best address both concerns.

The costs of applying specific water quality protection technologies has not been worked out nearly as well as for soil erosion technologies. Farmers will naturally be very concerned about the cost of implementing new practices. Adequate mechanisms to fund or provide cost-sharing for water quality protection have not yet been put in place.

V. REGULATION

The debate over whether to proceed with regulations versus pursuing voluntary adoption of new farm practices is more a policy question than a technical issue. Whether a regulatory or a voluntary approach is taken at this time, research will have to be done and farmers will have to be provided with educational programs and technical assistance.

I would guess, however, that most members of the research and Extension communities would prefer to develop an adequate research base and educational infrastructure before regulations are implemented. This is due in part to the tremendous environmental variability that exists among farming operations. For example, a farm that has clay soils and a very deep groundwater table will not be at the same risk of nitrate contamination from nitrogen fertilizers as a farm on sandy soils and a very shallow groundwater table. An "across-the-board" regulation that limits both farmers to the same fertilizer application rates and techniques would be nonsensical and could be counter-productive. I believe that the research community would prefer that regulations be based on the actual environmental parameters that will determine environmental risk, and this will require greatly expanded research efforts. I believe that the Extension and technical assistance communities will be anxious to get their programs up and running before regulations are put into place, so that when a farmer comes to them for help they will have something ready to offer.

VI. COORDINATION

I am often told that there is greater cooperation and coordination among and within the agencies to address water quality concerns than has ever occurred before. A number of organizations and committees are involved in facilitating this coordination, including the Office of Management and Budget, the Federal Coordinating Council for Science, Engineering and Technology, and an informal "Technical Integration Group" that consists of scientists and educators from the involved agencies. At the university level, scientists from a number of disciplines are working together on water quality projects. I assume that this rosy picture is in fact true. But I also know that there is concern in Congress and in the environmental community that these efforts are not enough, at least not enough to result in a comprehensive, integrated "package" of water quality protection programs. I believe that this is also true. How do I reconcile the two opinions? Easily, in fact they are not in conflict. Good efforts to coordinate and integrate water quality protection programs are underway, but they are still relatively "fledgling" efforts, and they need to be supported, protected, facilitated, and enhanced.

Questions have been raised regarding the relationship between the Water Quality Initiative and other relevant programs, such as Low-Input Sustainable Agriculture (LISA), Integrated Pest Management (IPM) and the use of biological controls. These are distinct programs, with unique objectives and goals. Their funding should be kept similarly distinct. On the other hand, I do not believe that we are integrating the planning or the implementation of these separate programs adequately. Consequently, we are missing the opportunity to fully capture the expertise and resources that each program has to offer to the others. This is understandable, allowing for the fact that new funding to specifically address water quality concerns only began last year. However, there are great opportunities to be explored.

Mr. Chairman, members of the subcommittee, I would be glad to answer whatever questions that I can.

VII. FIGURE

TABLE 1

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United States Department of Agriculture
Cooperative State Research Service
Water Quality Initiative
(Dollars in Millions)

ACTIVITY	FY 1988	FY 1989	FY 1990	
			Budget	Current Estimate
Targeted Initiatives				
Element I: Components Research	- -	- -	3.7	3.7
Element II: Midwest Initiative	- -	- -	3.0	3.0
Total, Targeted Initiative	- -	- -	6.7	6.7
Ongoing Programs				
Pesticides, Organics, Heavy Metals	3.2	4.0	2.8	3.3
Nutrients, Inorganics, Wastes	3.6	4.0	3.3	3.6
Biocontrol, Allelopathy,	1.9	1.9	1.7	1.9
Hydrology, Recharge, Irrigation, Soil/Water/Chemical/Plant Relations	5.3	6.3	5.1	5.4
Soil/Crop/Chemical Mgt. Systems, Socioeconomic, IPM	2.2	2.5	2.0	2.2
Other	0.4	0.8	0.5	0.4
Total, Ongoing Programs	16.6	19.5	15.4	16.8
CSRS Water Quality Efforts	16.6	19.5	22.1	23.5

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VIII. Background Material

The following materials are provided for reference and for background on some of the many activities that are underway in the States, that involve both the State Experiment Stations and the State Cooperative Extension Services.

(1) Groundwater Education and Extension Materials

- * Groundwater: What it is and how to protect it.
- * Nitrate: Health effects in drinking water.
- * Pesticides: Health effects in drinking water.
- * Modern Agriculture: Its effects on the environment.
- * Water and the soil.
- * Groundwater contamination.
- * Health effects of drinking water contaminants.
- * Disposal of household hazardous waste.
- * Our endangered water supply.
- * Water quality.

(2) Water quality resource materials catalog.

(3) Budget Recommendations: Cooperative Extension. Fiscal Year 1991

(4) CSRS-USDA Groundwater quality awards program: 1989 proposal selections.

(5) The Land Grant System and Related Organizations.

(6) State Agricultural Experiment Stations.

(7) Water Quality Research

(8) CSRS-USDA Groundwater Quality Awards Program: 1989 Proposal Selections

(9) Water Quality Program Plan to Support the President's Water Quality Initiative.

CSRS-USDA GROUNDWATER QUALITY AWARDS PROGRAM
1989 Proposal Selections

The 1989 process consisted of a solicitation for proposals of research on selected groundwater quality categories determined by committees of scientists and administrators in each of the four CSRS regions. Available CSRS funds of $1,754,827 were equally divided among regions. There were 23 proposals funded from a total of 237. The quality was very good, and there could have been many more awards had there been more funds. The following is a list of the successful titles, investigators, departments, institutions, general types of research and disciplines.

NORTH CENTRAL-- 6 Awards

19-077 Illinois/North Dakota. **Evaluation of Natural Abundance ^{15}N Techniques for Groundwater Nitrate Studies.** Vanden Heuvel and Mulvaney, Agronomy Department, University of Illinois; Prunty and Montgomery, Soil Science Department, North Dakota State University. Comparison of ^{15}N techniques for N identification in lysimeter and field studies. Disciplines: Soil Fertility, Soil Chemistry, Soil Physics, Soil Management. $46,005.

19-006 Iowa. **Availability of Organic Carbon for Denitrification of Nitrate in Subsoils and Groundwaters.** Bremner, Agronomy Department, Iowa State University. Organic carbon and denitrification of nitrate in subsoils. Discipline: Soil Biochemistry. $78,000.

19-098 Minnesota/Nebraska. **Integration of N Management Alternatives to Minimize Groundwater Contamination.** Malzer, Moncrief, and Robert, Soil Science Department, and Easter and Levins, Agricultural Economics Department, University of Minnesota; Hergert, and Schepers(ARS), Agronomy Department, and Martin, Agricultural Engineering, University of Nebraska. Produce software for adviser and producer use that is site and weather specific for N-Management recommendations, considering agronomic, environmental, and economic effects. Disciplines: Soil Fertility, Soil Management, Pedology, Resource/Environmental Economics, Extension Farm Management. $63,892.

19-129 Missouri. **Movement and Persistence of Pesticides in Highly Aggregated Soils.** Gantzer, Buyanovsky, Anderson, and Kapila, Agronomy Department, University of Missouri. Transport and degradation of pesticides in soils of high shrink-swell characteristics. Disciplines: Soil Management, Soil Microbiology, Soil Physics, Biochemistry. $65,220.

19-091 Ohio/Michigan. **Effect of Sorption on Fate of Pesticides in Subsurface Environments.** Traina, Sims, and Logan, Agronomy Department, Ohio State University; Boyd, Crop and Soil Sciences Department, Michigan State University. Biodegradation of pesticides and their persistence in soils and water. Disciplines: Soil Chemistry, Soil and Water Pollution, Soil Microbiology. $107,590.

19-074 Wisconsin. **Atrazine and Alachlor Movement Through the Unsaturated Zone: Model Calibration and Validation.** Daniel, Lowery, McSweeney, Soil Science Department, University of Wisconsin. Field and column validation of selected models for prediction of pesticide movement. Disciplines: Soil and Water Pollution, Soil and Water Management, Pedology. $78,000.

NORTHEAST-- 6 Awards

29-057 Delaware. **Leaching, Sorption and Bio-degradation of Herbicides in Subsoils of a Coastal Plain Watershed.** Sims, Sparks, and Fuhrmann, Plant Science Department , University of Delaware. Mobility, kinetics of sorption, and mineralization of pesticides in subsoils. Disciplines: Soil Fertility, Soil Chemistry, Soil Microbiology. $71,000.

29-068 Pennsylvania. **Nitrogen Fertilizer Rate and Manure Effects on Nitrate Leaching.** Fox and Fritton, Agronomy Department, University of Pennsylvania. Nitrate leaching and model evaluation from fertilizer and manure applications at economic optimum rates. Disciplines: Soil Fertility, Soil Physics. $77,750.

29-037 Pennsylvania. **Use of Microorganisms or Enzymes for Decontamination of Pesticide-Polluted Soil.** Bollag and Shu-Yen Liu, Agronomy Department, Pennsylvania State University. Develop method for microbial detoxication of the herbicide metolachlor in soil and water. Discipline: Soil Microbiology. $77,750.

29-026 New York. **Mapping Groundwater Contamination Potential Using Integrated Simulation Modeling and GIS.** Wagenet, Bryant, DeGloria, Hutson, and W. Waltman, Agronomy Department, Cornell University; Perritt, and S. Waltman, SCS, NY. Develop protocol to integrate GIS, simulation models, and soils maps, and make regional maps to show risk of pesticide leaching. Disciplines: Soil Physics/Solute Transport/Modeling, Soil Genesis/Classification, Soil Science. $80,000.

29-099 Vermont. **Effects of Different Corn Management Systems on Nitrate Leaching Potential.** Magdoff and Jokela, Plant and Soil Science Department; Clausen, Water Resources Research Center, University of Vermont. Nitrate leaching under best management practices, tillage, residues, manure, fertilizers and model validation. Disciplines: Soil Fertility, Hydrology. $76,706.

29-040 West Virginia. **Bacterial Quality of POU Filters for Treatment of Rural Groundwater Supplies.** Bissonnette and Anderson, Plant and Soil Sciences, West Virginia University. Bacteriological quality of rural water supplies with different management of activated carbon filters. Discipline: Agricultural Microbiology, research and extension. $55,500.

SOUTH-- 5 Awards

39-237 Arkansas **A GIS to Analyze Nitrate Contamination by Land Application of Poultry Litter**. Scott, Agronomy Department, Limp, Anthropology, and Cochran, Agricultural Economics, University of Arkansas. Develop GIS to integrate spatial relationships of soil hydraulic characteristics and chicken litter application on nitrate accumulation in soils and groundwater; assess economic impact of voluntary adoption of management practices or regulations. Soil Physics, Archeology(GIS applications), Resource Economics. $79,884.

39-160 Arkansas **Optimizing On-Farm Disposal of Pesticide Rinsates**. Lavy, Mattice, Wolf, and Talbert, Agronomy Department, University of Arkansas. Develop and test pesticide waste disposal methods designed for farmer use. Disciplines: Pesticide Chemistry Research and Extension, Soil Microbiology, Weed Science. $69,000.

39-166 Oklahoma/Florida **Agricultural Chemical Impact Evaluation and Management System**. Nofziger, Agronomy Department, Haan, Agricultural Engineering, Nelson and Norris, Agricultural Economics, and Miller, Forestry; University of Oklahoma; Hornsby, Soil Science Department, University of Florida. Interface chemical transport model and weather data with GIS for selected hydrologic units in Oklahoma and Florida, and demonstrate its use. Two Institutions/States; Disciplines: Soil Physics, Hydrologic Modeling, Environmental Chemistry and Soil Physics. $102,000.

39-163 South Carolina/Kentucky **Groundwater Quality as Affected by Preferential Flow in Structured Soils**. Quisenberry and Smith, Agronomy and Soils Department, Clemson University; Phillips, Agronomy Department, University of Kentucky. Macropore characteristics in soils, soil structure, and solute transport through the vadose (unsaturated) zone. Soil Physics, Soil Classification/Land Use. $102,000.

39-142 South Carolina/North Carolina **Terrain Conductivity to Quantify Impact of Farm Lagoons Upon Groundwater Quality**. Brune and Hegg, Agricultural Engineering Department, and White, Agricultural Engineering and Systems Engineering Departments, Clemson University; Westerman, Safley, Huffman, and Barker, Biological and Agricultural Engineering Department, North Carolina State University. Relate soil characteristics, variable pollutant levels, and specific conductivity to pollutant levels in soils and ground water, using electromagnet terrain conductivity(EM), (research is in collaboration with SCS). Disciplines: Water Quality and Environmental Engineering, Natural Resources Engineering, Groundwater Hydrology, Extension Water Quality and Waste Management. $85,823.

WEST-- 6 Awards

49-207 Arizona. **Management Practices and Preferential Flow Transport of Agricultural Chemicals.** Warrick and Watson, Soil and Water Sciences Department, Chernicky, Crop Science Department, and Lomen, Engineering Mathematics. University of Arizona. Determine and develop predictive capability on the influence of preferential flow on movement of herbicides and reactive chemicals through soils. Disciplines: Soil Physics, Extension Water Quality, Weed Science, Mathematics/Modeling. $78,000.

49-222 Montana. **Validation of Transport Models for Predicting Movement of Agrichemicals Through Soils.** Inskeep, Ferguson, Lockerman, Bauder, and Jacobsen, Plant and Soil Science Department, Montana State University. Mobility of agrichemicals in the field and in soil columns and, for soil mapping units, validate solute transport models for assessing chemical movement to groundwater. Disciplines: Soil Chemistry, Soil Physics, Plant Physiology, Extension Water Quality and Soil Fertility. $80,000.

49-208 Oregon. **Non-point Source Pollution and Agricultural Practices.** Boersma and Lindstrom, Soil Science Department, and Mason, Survey Research Center, Oregon State University. Develop a practical and scientifically sound data base system for application of agricultural chemicals over time, relate to soil properties, and describe fate and transport of chemicals in the soil mixing zone. Soil Physics, Mathematics/Modeling, Sociology. $76,110.

49-211 Utah. **Optimizing Irrigation Management for Pollution Control and Sustainable Crop Yields.** Dudley, Hanks, and Tindall, Soils and Biometeorology, and Peralta and Willardson, Agricultural and Irrigation Engineering, Utah State University. Interface numerical expression of chemical reactions in soils to water-solute transport model, including constraints on salinity and other contaminant movement below the root zone, and transfer irrigation management schemes to users. Disciplines: Soil Chemistry, Soil Physics, Extension Soils, Water Management, Irrigation Engineering. $78,000.

49-201 Washington. **Development of a Spatial Decision System for Farm Management of Nitrogen Fertilizer Applications.** Mulla and Campbell, Agronomy and Soils Department, Washington State University. Develop a decision aid for water and nitrogen movement under irrigated corn and potatoes, with the potential of variable N application for parts of fields. Discipline: Soil Physics and Biophysics, Soil Microbiology/Fertility. $78,200.

49-197 Washington/Oregon. **Managing Nitrate--Groundwater Pollution from Agriculture in the Pacific Northwest.** Whittlesey, Agricultural Economics Department, Washington State University; Adams and Perry, Agricultural and Resource Economics, and Istok, Agricultural Engineering, Oregon State University. Develop water quality assessment framework for crop and water management; evaluate changes in farm management strategies and net farm income from changed N fertilizer use in response to environmental concerns. Disciplines: Production and Resource Economics, Soil and Water Engineering. $48,397.

STATEMENT BY EDGAR W. DUSKIN, EXECUTIVE VICE PRESIDENT, SOUTHERN AGRICULTURAL CHEMICALS ASSOCIATION, DAWSON, GEORGIA.

Senator Fowler, other members of the Committee:

SACA appreciates the opportunity to give its view on groundwater protection, especially concerning the proposals set forth in your bill S-970.

Southern Agricultural Chemicals Association (SACA) is an independent, regional trade association composed of formulators, distributors, basic manufacturers of agricultural pesticides, & suppliers of products and services to the industry. The Association's membership represents over 90 percent of those companies in the aforementioned categories which operate in thirteen southern states extending from Delaware-Maryland across the South to include Louisiana & Arkansas across the Mississippi.

First of all, our industry is vitally concerned that we continue to have the safest water available for drinking, irrigation, industrial, and recreational uses. Groundwater with a potential drinking water deserves the highest degree of protection. We believe this use should be the principal focus of any groundwater legislation.

Unfortunately, at this time there is insufficient reliable information on the extent and causes of groundwater contamination. For this reason we urge the congress to focus **first** on legislation which will generate an accurate understanding of the problem. Proper management of this would necessitate some type of coordinated - I emphasize the word **coordinated-** approach among all agencies involved.

The public needs to be able to understand the significance - or even more important - the lack of significance of the mere detection of a pesticide or chemical contaminant. The EPA should be encouraged to speed up and expand its program of developing Health Advisories and eventual Maximum Contaminant Levels (MCL) for all toxic pollutants.

We believe Federal guidelines and standards implemented by States, each according to its situation and needs, is the only practical approach to regulation.

We believe a "trend analysis" approach to remedial action is preferable to a fixed trigger such as percentage of a Preventive Action Level (PAL).

This would allow discretion on the part of the regulatory agency to tailor preventive and corrective action to the need at hand and not force regulatory action upon a one-time detection of a negligible amount of contaminant.

Most reputable scientists in the field, as well as the EPA in its groundwater strategy, (which, by the way, provides a pretty good basis for a just regulatory program) oppose a total non degredation approach since this usually translates into a required remedial and corrective action upon detection at any level. With the ever improving analytical capability, it will eventually be possible to find virtually any element at some level. Zero continues to recede.

We support Best Management Practices (BMP) which would allow tailoring of agricultural chemical and fertilizer use to the conditions at a specific site. Such should be a part of any regulatory scheme.

We strongly support a program which would recognize the contamination dangers provided by sink holes and urge consideration of a program which would also provide assistance in closing abandonned drinking water and other wells. This is of particularly importance in the South. These two sources we believe ultimately will be found to be the major source of groundwater contamination, rather than leaching per se. We believe testing of shallow private drinking water wells is best handled under state programs and should not be a part of Federal Legislation.

In summary we urge action based only on good scientific knowledge. We urge management responses tailored to site specific conditions. We urge that the government make a major effort to educate the general public about the significance or insignificance of the mere finding of a contaminant in groundwater and to set recognized health based standards. A coordinated, adequately funded research program should be a top priority to obtain accurate groundwater information so that regulatory responses can be based on knowledge rather than emotion.

TESTIMONY OF

DR. JACK EARLY, PRESIDENT

AND

MR. JAY VROOM, EXECUTIVE VICE PRESIDENT

OF THE

NATIONAL AGRICULTURAL CHEMICALS ASSOCIATION

Before the
United States Senate
Committee on Agriculture, Nutrition and Forestry
Subcommittee on Conservation and Forestry

October 24, 1989

Mr. Chairman, on behalf of the National Agricultural Chemicals Association (NACA), I am pleased to be here today to share with you our views on the quality of our ground water, the role of the federal and state activities to protect ground water and the need for additional education and research to enhance our ability to prevent the movement of agricultural chemicals into ground water.

As an association representing more than 80 companies, our members are involved in every aspect of the production, distribution and sale of a wide variety of agricultural pest control products including virtually all of the technical or basic active ingredients used in agriculture. NACA has had an active ground water protection program since 1983. This year our Board of Directors voted to devote 40 percent of our time and resources to the ground water protection issue. I assure you, Mr. Chairman, that we take the protection of our ground water resources very seriously.

In the way of background, let me say that the efforts of our member companies begin long before a product is sold. As you know, federal registration for pesticides involves the development and submission of exhaustive information about the product, including data on hydrolysis, photolysis in soil and water, aerobic and anaerobic effects and other information on environmental fate. For older products, where EPA believes further information is needed, we also must supply this data on EPA's request.

Companies in our industry are also monitoring for residues in ground water as part of product stewardship. These companies recognize that it is in their interest, in order to continue marketing products responsibly, to know in advance about potential adverse effects. Many of these companies are engaged in costly and extensive monitoring programs.

Along with various federal and state agencies, we are also conducting extensive research on the conditions for products leaching into ground water. This is an effort to collect physical, chemical, and biological data and other information that may indicate the potential for products to leach, as well as developing models and statistical analyses for prediction.

An important aspect of this information-gathering effort is in relating actual pesticide usage, environmental and other conditions to detections and nondetections of pesticides in ground water. Our experience has been so far that there are surprising inconsistencies and unknowns in this kind of information. This is true especially with point source contamination from spills, well back-flows, drainage wells, poorly constructed wells, and sink-holes -- distinguished from non-point source contamination from normal pesticide applications. The weakness of some monitoring programs to date is that they fail to consider agricultural practice, soil and weather conditions, and actual water and pesticide use. And, many of these same studies do not extend over sufficient time periods. Without sufficient investigation, background and coordination, improper conclusions may be drawn about the real causes and significance of ground water contamination.

As we learn more about the potential for pesticides in ground water, our industry is also developing strategies on minimizing the entry of pesticides into ground water.

We are proud of our record in educating our customers on responsible pesticide use and ways to avoid having agri-chemicals get into ground water. You may already know of the NACA booklet entitled, 'Protecting Our Groundwater - A Grower's Guide.' It was jointly developed by NACA, USDA, the American Farm Bureau Federation, and the National Agricultural Aviation Association.

We are assisting USDA Soil Conservation Service (SCS), USDA Cooperative Extension Service (CES), and EPA, in the development and funding of a conference to provide farmers with the information they need for making ground water management decisions.

Member companies of NACA have also established the Alliance for a Clean Rural Environment (ACRE) as a separate industry ground water educational resource for pesticide retail dealers, commercial applicators and farmers. Attached to my testimony is a brochure and fact sheets which explain the goals and efforts of ACRE.

For several years, NACA has actively worked with EPA, and federal and state Agricultural Extension Service personnel to encourage applicators and agricultural producers to attend state-sponsored certification training programs. These programs are designed not only to improve grower understanding of ground water issues, but also to provide practices and procedures to reduce potential ground water contamination from agricultural chemicals. We believe that these state-sponsored certification training programs are key to ground water education.

Also, with the objective of providing a benchmark for assessing the impact of pesticides in ground water, NACA has been actively working with EPA to develop and publish 'health advisories'. It is important to note that whenever EPA develops a numerical standard, very large safety factors are calculated. To date, EPA has published health advisories for 61 pesticides as part of the Agency's National Pesticide Survey.

NACA is cooperating with the USDA Agricultural Research Service (ARS) in establishing a pesticides properties database for public use in water quality (ground and surface water) modeling. The inputs to this database are actual environmental fate data from NACA member companies on their respective products.

NACA is assisting the USDA Soil Conservation Service (SCS) in developing a preliminary ground and surface water assessment methodology using the combined properties of pesticides and soils. This methodology, referred to as the SCS Soil and Pesticide Interaction Rating System, is being developed by SCS to assist farmers in better understanding and assessing water quality vulnerability in the use of pesticides, taking into consideration site specific and pesticide specific factors.

NACA has also recommended, for EPA and state regulatory agency use, a tiered approach for assessing ground water vulnerability to pesticides. The tiered approach starts with a preliminary screen of agricultural areas (tier 1), similar to the SCS Soil and Pesticide Interaction Rating System, and proceed to more refined assessments through the use of transport models (tier 2) and finally actual ground water monitoring (tier 3), if and where prescribed conditions and criteria dictate.

Very specific to the subject of research, NACA is currently working with the Agricultural Research Institute (ARI) to sponsor a workshop in March 1990 on agricultural ground water research. The purpose of the workshop is to promote better communication and coordination among representatives from federal and state governments responsible for ground water policy development and implementation, public interests, the research community, and agricultural producers to increase their mutual appreciation of each other's respective decision making processes, understanding of the role of research results in developing and implementing ground water policy, and awareness and use of existing science information resources in agricultural ground water policy and management decision making processes. We invite you and your staff to participate in the workshop and we will certainly share the findings of the workshop with you.

Finally, with respect to our efforts to reduce any potential for harmful contamination of ground water, our companies are trying to develop new products, formulations, and applications technology. Much of the R&D dollars being spent are in focussed upon looking for materials that have less chance of entering groundwater by being less persistent and biodegrade more rapidly in the soil, have reduced use rates and can be more specifically targeted and more easily cleaned-up if accidentally spilled.

Again, public and private efforts in determining the cause of ground water contamination are key to developing new products and application techniques. The federal government's research efforts on ground water are, thus, a critical part in our mutual efforts in helping to preserve a reliable and abundant food supply.

NACA agrees that ground water policy should focus on prevention. The success of such a policy is dependent on the effectiveness of actual policy implementation strategies and programs through appropriate use of science based risk assessment and management procedures and practices. It is essential that we have the appropriate information and understandings to assure that correct decisions are made, first for identifying and prioritizing problems, and second in managing them.

Prior to defining future research, we believe it is only prudent that efforts be made to maximize the use of existing research results. There is a great deal of scientific information that already exists for assessing and preventing ground water contamination such as the programs outlined above in which NACA is participating. It would be a waste of resources if this information is ignored, duplicated, or not properly communicated to those in need of it. Furthermore, it is essential that before new research is defined, society needs a clearer understanding of what information is needed and how it is to be used in ground water policy development and implementation decision making processes. This would foster the proper use of existing scientific information and establish a basis from which improvements, i.e. new research, can be defined.

Institutional factors have an important impact on the quality, i.e. responsiveness to ground water management needs, and efficiency of what actual research is conducted. It is important that uniform guidance and coordination be provided to the many entities in the private and public sectors conducting ground water research. Concerning agricultural impacts on ground water, NACA believes that the USDA, in coordination with state governments, agricultural producers and industry, should have primary research responsibilities. Other agencies, such as USGS and EPA, should work with and compliment USDA research initiatives within their respective areas of expertise and ground water research responsibilities.

As you know, a number of states have recently passed comprehensive ground water statutes. Each law requires continued availability of data from the federal government. NACA believes that one of the most important functions the federal government can perform is the proper dissemination of information to the states to enhance their ongoing efforts.

It is encouraging to report that during this past year, the USDA, USGS, and EPA began meeting on a regular basis to coordinate their respective ground water research initiatives on agricultural chemicals. This effort is to be commended and hopefully is the start of similar efforts throughout all of ground water research.

Mr. Chairman, we would like to commend you for your interest in addressing this issue. With regard to the ground water provisions in your bill, S. 970, it is my understanding that generally your bill directs the Secretary of Agriculture to establish a well testing program for domestic wells and calls upon the U.S. Extension Service to play a larger role in developing outreach and education programs for farmers. We support your efforts to strengthen the role of USDA and Extensive Service and believe that well testing is an important tool in any prevention program. While, EPA has recently undertaken a nationwide well testing survey of both domestic and public drinking water wells, we believe that more can be done to broaden our knowledge of the quality and nature of groundwater and establish a more extensive baseline of information.

We are concerned, however, over the ability to determine from a single well sample, the source of any possible contamination or the true extent of a possible problem. Any regulatory actions taken on the basis of a one time sampling of a limited number of wells could lead to inappropriate conclusions and unfair punitive actions. Also key to survey information are well designed sampling techniques.

As an example of this concern, I would like to bring to your attention our recent experience involving the Big Springs Basin in Northeast Iowa. The reporting in 1982 to 1985 of ground water monitoring results (the Big Spring Basin Study) presented conclusions that several common corn herbicides appeared in ground water as a result of leaching following their normal field application. This report has been widely referenced as evidence of a nationwide problem. More recent data obtained by the Iowa Department of Natural Resources on the Big Springs Basin includes monitoring results from the years 1986 to 1988. These data, combined with the 1982 to 1985 data, have been reviewed by two independent groups, an engineering firm as well as the Iowa State University. As explained in the summaries, which I will leave with you, the new data does not support the earlier conclusions. From these more recent evaluations, it is evident that in the Big Springs Basin:

1. The numerous sink holes present are a dominant transport mechanism to the shallow ground water;
2. Infiltration of pesticides through the soil appears to a minor component, if it occurs at all;
3. Trends in pesticide levels of detection are not increasing; and
4. The Big Spring information can not be used to predict the fate of pesticides in other areas with differing geographical characteristics.

I trust that you will find this information of interest and value. We bring it to your attention today, to emphasize the need to use good sound science in managing our water resources and the fact that, despite years of effort and research, there is a great deal about ground water that we do not know. Finding appropriate answers to these questions is an essential first step in developing an effective prevention program.

Thank you, Mr. Chairman, for this opportunity to share with you some of our activities and thoughts on the issue of ground water protection. I would be happy to answer any questions you or other members of the Subcommittee might have.

Statement

of

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Before the
U.S. Senate
Committee on
Agriculture, Nutrition, and Forestry
Subcommittee on Conservation and Forestry

October 24, 1989

Mr. Chairman and Members of the subcommittee, the National Audubon Society appreciates this opportunity to testify on the critically important issue of ground water protection. We commend you, in particular, Mr. Chairman, for your leadership in making ground water protection a central issue in the 1990 Farm Bill debate.

Your efforts to focus attention on the problem of contamination of ground water by agricultural chemicals has raised many questions, such as who should pay for private well testing, and whether or not the results of these tests should be confidential. National Audubon welcomes the opportunity in this hearing to explore ground and surface water protection more broadly. As requested, we will focus our testimony on research, data collection, education, technical assistance, and regulation.

Introduction

Ground water in the United States is a valuable resource comprising 96 percent of the freshwater available for use. While much of this resource is untapped, ground water currently accounts for about 50 percent of the drinking water consumed and is the major source of drinking water for 97 percent of the rural population. Ground water use is also increasing at twice the rate of surface water use. Almost all of the ground water overdrafts have occurred in agricultural areas, increasing the importance of ground water protection in our rural communities.

Recent monitoring has revealed that ground water is becoming more contaminated by agricultural chemicals, with 46 pesticides detected and confirmed in the ground water of 26 states due to agricultural use in 1988. Since 12 different pesticides were detected in 18 states in 1984, and 17 pesticides were found in the ground water of 23 states due to agricultural practices in 1986, it is to be expected that the number of pesticides found in ground water will increase with time. (See attachments on states with ground water contaminated by nutrients and pesticides (from the second Resources Conservation Act appraisal, October 13, 1989, compiled by the University of Oklahoma; and a list of pesticides found in ground water, from the National Academy of Sciences NRC Report on Alternative Agriculture)

Between 1965 and 1985, crop production evolved to an increasingly capital-intensive industry, and pesticide use in the U.S. tripled. In 1985 farmers applied over a half billion pounds (active ingredients) of pesticides on 13 major field and forage crops in 33 states. Since chemicals applied to the soil were made directly available for transport to ground water, it was only a matter of time before intensive cropping practices resulted in ground water contamination.

The mechanisms for transport of agricultural chemicals to ground water is now becoming clear. In some instances, point sources of contamination are the problem. However, a body of information is now emerging on vertical and lateral water and chemical transport and retention which points to widespread nonpoint sources of ground water contamination. A significant fraction of pesticides applied to soil can move rapidly downward, reaching depths of up to 10 times greater than previously believed. (Jury, Elabd, Clendening and Resketo, 1985) This gravitational transport occurs even in clay. In Brookings, South Dakota scientists constructed nine-foot culverts to measure the vertical movement of agricultual chemicals and water. Flowing through cracks, worm holes and fissures, nitrates and pesticides have been detected 10-15 feet below the surface just two days after application. (Bender 1989) Investigations in Minnesota, Ohio, Indiana and Arizona also indicate that macropores, especially large worm holes, are important conduits for rapidly infiltrating water and soluble pesticides. After the fifth year of no-till farming in the Corn Belt, the number of worm holes increase from 2 percent to 12 percent and this increase continues at least through year 21, the most recent year of such longterm monitoring. It does little good to apply a wormicide or plug the holes, because large channels remain for years after disuse, they may extend downward directly to sedimentary bedrock, and the number of holes increase with depth. (Edwards, Norton and Redmon, 1988)

What is perhaps most striking about the new understanding of groundwater contamination mechanisms is the potential scope of contamination as a result of normal farming activities. 1,437 counties have been identified by USDA as vulnerable to groundwater contamination with pesticides or nitrates.

Two broad types of groundwater pollution phenomena are of special relevance to agriculture. One is the contamination occurring in agricultural areas that possess sinkholes, where agrichemicals or livestock waste can cause contamination. The other, more extensive problem is the contamination of aquifers arising from normal use of pesticides and fertilizers. In the first category, changes in land use, or relocation of agricultural activities or facilities may be the most satisfactory solution. To deal with the problem of widespread ground water pollution threats, however, will require equally widespread changes in agrichemical usage patterns.

Nonpoint source groundwater and surface water contamination can be dealt with in a number of ways. At present, society is tending to allow the damage to occur and is treating the problem after the fact. For example, sediment eroding from cropland is causing an estimated $2.2 billion (1980 dollars) in damage after it leaves farm fields, largely through siltation of water conveyances, streams, lakes, and reservoirs. In some cases the damages cannot be repaired, and in others society pays by removing the sediment or replacing the sediment-impaired facility. Similarly, ground water contamination of rural wells could be remediated to remove contaminants, but at prohibitive cost.

A more cost effective approach would be to reduce the threat of contamination at its source by reducing the use of potential contaminants in agricultural production. As noted in testimony presented by Audubon and the Center for Resource Economics before the Subcommittee on Agricultural Production and Stabilization of Prices (September 21, 1989), evidence suggests that farmers routinely overfertilize their crops with synthetic fertilizers, even when they simultaneously apply manure to their fields. Pesticides have similarly been applied unnecessarily. Reduction, not elimination, of the use of these chemicals is the logical first step in protecting the nation's groundwater from agricultural contaminants.

Research Needs

Source reduction of agricultural pollutants, including those that threaten groundwater, should be a major priority of agricultural research over the next decade. Some of the required research is basic, but most will be applied. The applied work should be disseminated much more quickly and efficiently than resource and environmental protection information have been disseminated to farmers in the past.

Areas of agricultural research for ground water protection include the following:

a. Multidisciplinary integrated pest management research, centered on the development and use of biological pest control. This will require nothing less than fundamental reform of existing IPM research efforts, followed by significant expansion of funding. A framework must be established which balances basic goals with applied IPM research. Reduction of pesticide usage must be a priority of a reinvigorated IPM program.

b. Multidisciplinary research to identify and quantify agricultural pollutant sources and to develop source reduction techniques for a wide range of farm products and farming systems. These techniques may vary from improved, site-specific methods for soil testing to more accurately determine fertilizer needs, to research on crop rotations and animal waste utilization.

c. Long-term research to develop agroecosystems that utilize renewable sources of energy and emphasize biological means of pest control and plant and animal nutrition. This should include research into new crops, including perennial grains.

d. Research to improve identification of watersheds and fields within watersheds that are vulnerable to groundwater contamination. This research should be coordinated with the IPM and source reduction research efforts described earlier.

Data Collection

The detection of carcinogens in food and water has raised serious concerns about the safety of food and drinking water sources. Reliable data and analyses are important to assess problems and verify the extent of pesticide residues in food and water. Pesticide use data, however, generally have been nonexistent. In a number of instances, most recently in the case of the Alar controversy, the lack of reliable usage data has severely compromised the integrity of the Environmental Protection Agency's pesticide efforts. It is a fact that the Agency simply guessed -- apparently very badly -- on the critical question of how much of the nation's apple crop was treated with Alar. The credibility of both the Agency and, more importantly, the apple growers themselves, was severely damaged by reliance on guesswork about usage levels. Information on usage is fundamental to defensible assessment of the risk _any_ chemical poses in the environment. Unfortunately, it has been farmers who have paid the price in the regulatory arena for lack of information about pesticide use. It is absolutely critical that accurate, comprehensive use data be obtained and made available for analysis.

Such data might be obtained in several ways. For pesticides, farmers should be required to maintain records, including total amount, rate, and number of times pesticide products are used each year, by field and by crop. USDA and EPA should be responsible for periodic sampling of the records, in order to develop accurate estimates of on farm pesticide usage patterns. Records should be available to state and federal regulatory agencies. EPA and USDA should also share responsibility for the development and maintenance of a database comprised of the periodic usage survey data to enable industry, farm, and other interested parties to analyze pesticide usage patterns. For efficiency, this database should probably be maintained by the National Agricultural Library. Periodic surveys of usage data should be integrated with yield surveys conducted by the National Agricultural Statistics Service, the National Resources Inventory (NRI) compiled by SCS, and with other data collection efforts in order to develop a more comprehensive information base for analyzing resource-environment-production relationships in agriculture. Accurate use data must be obtained and analyzed in a comprehensive way.

As collection of actual chemical use, related agricultural practices, and hydrologic and physical properties of cropland is developed and integrated, such information could be used to develop management practices and options for how, when, and at what rates pesticides are used. Such a data base could also be used to identify areas for special attention, research and extension activities.

At present, federal law does not provide for regulation of commercial fertilizers, or for collection of data on the use of those products. In view of growing concerns about nitrate contamination of ground water, and about other water quality impacts from intensive use of both fertilizers and animal manures, there is a need to develop more reliable estimates of on-farm usage. These could be integrated in chemical usage data.

Education and Technical Assistance

Many private efforts have recently been undertaken to educate and inform farmers about ways to protect ground water. For example, the Farm Bureau, the National Agricultural Chemicals Association, the U.S. Extension Service and the National Agricultural Aviation Association have jointly published a pamphlet to promote safe pesticide handling practices.

Many believe that education is the key to protection of ground water, for farmers are the ones living on the land and obtaining drinking water from ground water sources. Therefore they are vitally interested in protecting their ground water. While this is true, farmers do not necessarily have a choice, given conventional patterns of agrichemical usage, the absence of regulation, and in some cases, the modest cost of fertilizers and pesticides. Farm programs also provide an incentive to use more and more chemicals each year to maximize production. The range of alternatives farmers can chose from should not put him/her at a disadvantage in relation to his neignbors. In addition to education, farm technical assistance is needed. Many farmers have expressed their willingness to reduce chemical use, and to protect their ground water by adopting crop rotations, strip cropping, interplantings, grass diversions, filterstrips, etc. But they need technical and financial assistance from USDA.

The recent, landmark report, Alternative Agriculture, produced by a committee of the National Research Council's Board of Agriculture, has proposed a number of ways by which education and technical assistance can be improved to help farmers use fewer purchased inputs, many of which are potential pollutants. Natural sources of contamination will also need to be taken into account when devising education and technical assistance efforts.

As investigations of options for education and technical assistance proceeds, we urge that the following assumptions be kept in mind:

1. Education and technical assistance work too slowly and unevenly to reduce groundwater and surface water pollution in the absence of meaningful incentives and disincentives to influence farmer behavior. This is the lesson that can be drawn from over 50 years of technical assistance and education for erosion control prior to the incentives and disincentives contained in the Food Security Act of 1985. Despite some serious problems in implementation, soil conservation has been very visibly advanced since the 1985 Farm Bill. Technical assistance and education efforts were given new meaning and urgency after passage of the Act. Those lessons will be relevant to water quality.

2. Overall responsibility for technical assistance and education programs for source reduction of agricultural pollutants should reside in a single agency: the Soil Conservation Service. Activities and personnel in other agencies, most notably the Extension Service, should be transferred to SCS if a concerted source reduction effort is to be facilitated in U.S. agriculture.

3. A major expansion and redirection of existing technical assistance and education capabilities will be needed to encourage the adoption of management that relies on less chemicals. These efforts will require a substantial increase in funds and personnel, and a much more direct involvement on the part of farmers. Even with improvements in efficiency and appropriate incentives and disincentives, a large technical assistance and education effort will be required.

Another approach is a variable set-aside, introduced in a hearing before the Subcommittee on Agricultural Production and Stabilization of Prices on September 21, 1989 by Ken Cook of the Center for Resource Economics. Set-aside requirements would be scaled up for specialized farmers and down for diversified operators. Unlike current set-aside requirements which are applied across the board for all farmers, regardless of size or degree of specialization, the variable set-aside would gradually increase production adjustment requirements for specialized farmers.

A second approach put forth by Ken Cook is a successor to CRP, the Environmental Stewardship Program (ESP). The ESP could be an acceptable rotation schedule for the entire farm, or a longterm integrated pest management system built around biological controls. An example of an acceptable rotation would be a 3-4 year rotation with at least one year of a grass/forage crop and/or small grain, which would be credited with a 15 percent increase in established yield for the principal crop (usually corn, wheat, or cotton) in the year of rotation when crop is grown.

The great need for new approaches may bring forth other creative ideas.

Regulation

Without an effective program of ground water protection, greater regulation will be necessary. Even now, agriculture which has traditionally been exempt from pollutant discharge permitting is being regulated as a polluting industry in Florida. In that state, if a discharge from an agricultural field, ditch or canal threatens to violate ground water standards "at the boundary of the zone of discharge, or otherwise threatens to impair the designated use of contiguous waters," the owner must obtain a ground water permit defining the zone of discharge and implement a ground water monitoring plan. (Aller, 1989)

More states can be expected to assume such regulatory powers to protect the integrity of their ground water. Florida also requires communities to conduct water testing, with priority on drinking water supplies, high recharge areas and single-source aquifers. Iowa requires disclosure of well test results at the time a farm is sold. Minnesota implemented comprehensive well testing and monitoring studies funded by the Legislative Commission on Minnesota Resources and EPA. One Minnesota township launched its own domestic water well program which cost $50.00 per well for a broad spectrum water analysis. Obviously the more testing, the less costly per test, but the cost of a national program could be as high as $1.2 billion for a one-time test for 2.2 million farms. Even if it is possible to reduce the cost to something like $220 million (with two tests per farm) for mass tests, the total would be far higher than the costs of annual collection of reliable use data described above.

We do not intend to imply that well testing is unnecessary. Farmers should know what is in their water, but it would be more cost effective to reduce the possibility of contamination by reducing the use of potential contaminants.

Conclusion

We urge this committee to explore and create incentives in the 1990 Farm Bill to encourage farmers to reverse the trend of contamination of ground water from agricultural chemicals. We look forward to working with you to develop policies for the 1990s that will increase profitability of farming, protect resources, bring back diversity to the rural landscape, and improve the health of the rural economy and rural residents.

Thank you.

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Table 36.--Ground water contamination by nutrients and pesticides ("n" means nutrients; "p" means pesticides. Absence of an entry indicates either that no significant contamination is apparent or that data were not available.)

Region	State	Confirmed 1/ Regional	Confirmed 1/ Localized	Suspected	Nonagricultural 2/
NORTHEAST:	Connecticut	n, p			
	Delaware	n	p		
	Maine	n, p			
	Maryland		n, p		
	Massachusetts	p			
	New Hampshire				
	New Jersey	n, p			
	New York	n, p			
	Pennsylvania		n, p		n
	Rhode Island	p			
	Vermont		n, p		
LAKE STATES:	Michigan		n, p		
	Minnesota		p	p	n
	Wisconsin		n, p		
CORN BELT:	Illinois		n, p	n, p	
	Indiana		n, p		
	Iowa	n	p		
	Missouri		n, p		
	Ohio		n, p		
NORTHERN PLAINS:	Kansas		n, p		
	Nebraska	n, p			n
	North Dakota				
	South Dakota	n, p			n
APPALACHIA:	Kentucky			n, p	
	North Carolina		n		p
	Tennessee		n, p		
	Virginia			n, p	
	West Virginia		p		
SOUTHEAST:	Alabama		n, p	n, p	
	Florida	n, p			
	Georgia	n	p		
	South Carolina		p		n
DELTA STATES:	Arkansas				
	Louisiana		p		
	Mississippi				
SOUTHERN PLAINS:	Oklahoma	n			p
	Texas	n, p	n, p		
MOUNTAIN:	Arizona		p		n
	Colorado		n, p		
	Idaho		p	p	n
	Montana		p		
	Nevada				n
	New Mexico		n	p	
	Utah		p	n	
	Wyoming			n, p	
PACIFIC:	California	n, p			
	Oregon 3/	n, p			n, p
	Washington	n, p			
	Totals:	15n, 13p	16n, 25p	6n, 8p	9n, 3p

1/ Contamination has been documented by ground water monitoring or by published studies.
2/ Contamination exists but is due to handling or to nonagricultural activities (for example, phosphate mining).
3/ Data added by the state.

Ground water naturally contains various mineral substances that have been dissolved from the local geologic formations. In general, the longer the water remains in the earth, the higher the concentrations of dissolved substances. Water in deep aquifers thus tends to be more mineralized than water in shallow aquifers. Faults in rock systems may act as conduits for ground water flow or may be sealed so tightly with clay or mineral deposits that the ground water flow is blocked.

Improper disposal of manmade waste or overapplication of other materials may add extraneous substances to ground water. These actions may degrade the quality of the ground water so that it no longer meets standards for a specific use.

In 1984, forty-two states reported some information on ground water conditions. 4/ This information is largely anecdotal and must be tied to information gained through other studies. Thirty-five states reported some problems with ground water contamination. The most commonly reported sources of contamination are industrial and municipal landfills and lagoons, underground storage tanks, pesticide applications, septic tanks, and chemical, oil, and brine spills. The most commonly reported pollutant groups are chlorinated solvents, pesticides, miscellaneous hydrocarbons (such as gasoline), metals, salinity, and radionuclides. Several states reported problems with ground water depletion and saltwater intrusion.

Contamination of Ground Water by Agricultural Chemicals

Although there is no national data base to confirm it, there are examples of the contamination of ground water by nonpoint sources. Ground water pollution from prior and current agricultural use of pesticides and nutrients is being documented. Synthetic organic pesticides are of concern because of their environmental persistence and potential health effects. Nitrates in ground water from fertilizer applications and animal waste have long been recognized. Table 36 summarizes a report on ground water contamination by agricultural chemicals that was prepared for this appraisal by the Environmental and Ground Water Institute of the University of Oklahoma. The agricultural chemicals studied were pesticides and nutrients (primarily nitrogen) originating from applications of fertilizer or of animal wastes.

Many states have only limited information on pesticides and nutrients in ground water. However, interest in these contaminants is increasing, and many efforts to gather data are under way. Limited funding for monitoring programs appears to be a major cause of this lack of knowledge. Many field studies have been conducted across the Nation on agricultural contamination of ground water, but most of them focused on nutrients. Information is being accumulated on management practices that reduce loss of nitrate fertilizer to ground water. Pesticide contamination has drawn less attention. Research on the stability and transport of pesticides in ground water is increasing.

A large number of states do not have laws or regulations governing the application of pesticide or fertilizer. Many existing laws and regulations need updating. In some states the institutional authority for addressing pesticide contamination of ground water is still unclear.

At present, nitrates in ground water are regulated under stricter standards than are pesticides. The large number of pesticides and the lack of information on their persistence in ground water make it difficult to set standards defining pesticide contamination.

Several federal laws directly address agricultural chemicals. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) allows EPA to ban or restrict pesticides that pose an imminent risk because of their ability to leach through the soil profile. Under the Safe Drinking Water Act, states are to develop programs for preventing contamination of ground water around public wells.

Saltwater Intrusion into Ground Water

Water obtained from wells is frequently contaminated by saltwater intrusion. The salinity of ground water generally increases as depth increases. This phenomenon is related to the original deposition of the salt-bearing formations, the movement of ground water, and the movement of individual ions over time.

However, the salinity of ground water is also traceable to other factors, such as proximity to oceans, leakage of wells, upconing of salt under wells, and leaching from surface sources. 5/ The effects of salinity may extend for 20 or 30 miles or even more from the source of the salinity toward the area where ground water is being withdrawn.

In 1977, the Environmental Protection Agency conducted a survey of saltwater intrusion. The EPA study does not include a precise assessment of intrusion linked to surface infiltration from agricultural practices. The most frequent cause of saltwater intrusion is excessive pumping, or ground water mining, which has caused lateral intrusion of salt water in 27 states and vertical intrusion in 11 states, according to the EPA study. Agriculture is not implicated except as a heavy user and consumer of water. Other sources of saltwater intrusion, reported in only a few states, are improper disposal of oilfield brines, faulty well casings, layers of salt water in thick limestone formations, and dredging (which may cause vertical intrusion or upwelling of salt water). Of these, only faulty well casings (six states affected) may relate to surface infiltration from irrigation.

4/ U.S. Environmental Protection Agency. 1984. National water quality inventory: 1984 report to Congress.

5/ For additional discussion of saltwater intrusion problems, by state and region, see Environmental and Ground Water Institute, University of Oklahoma. "Salt water intrusion of ground water in the contiguous United States," Chapter IV, Volume III, Part A.

TABLE 2-7 Confirmed Pesticide Detections in Groundwater Due to Normal Agricultural Use

Pesticide	Health Advisory Level[a] (parts per billion)	States	Median Concentration[b] (parts per billion)
Alachlor	1.5[c]	CT, FL, IL, IA, KS, LA, MA, ME, NE, PA, WI	0.90
Aldicarb	10	CA, FL, MA, NC, NY, RI, WI	9.00
Aldrin		MS, SC	0.10
Arsenic		TX	N/A
Atraton		MD	0.10
Atrazine	3.0	CA, CO, CT, IL, IA, KS, MD, ME, NE, NJ, PA, VT, WI	0.50
BHC		MS	2.70
Bromacil	80	CA, FL	9.00
Carbofuran	36	MA, NY, RI	5.30
Chlordane	0.03[c]	MS	1.70
Chlorothalonil	1.5[c]	ME, NY	0.02
Cyanazine	9.0	IA, LA, MD, NE, PA, VT	0.40
1,2-D	0.0013[c]	CA, CT, MA, NY	4.50
1,3-D	0.20[c]	NY	123.00
2,4-D	70	CT, MS	1.40
DCPA	3,500	NY	109.00
DDT		MS, NJ, SC	1.70
Diazinon	0.63	MS	162.00
Dibromochloropropane	0.02[c]	AZ, CA	0.01
Dicamba	9.0	CT, ME	0.60
Dieldrin	0.00219[c]	NE, NJ	0.02
Dinoseb	7.0	MA, ME, NY	0.70
Diuron	14	CA	N/A
Endosulfan		ME	0.30
Ethoprop		NY	N/A
Ethylene dibromide	0.0005[c]	CA, CT, GA, MA, NY, WA	0.90
Fonofos	14	IA, NE	0.10

(Table 2-7 continued on page 108)

have contaminated water based on high susceptibility to contamination and fertilizer use (Figure 2-9) (Nielsen and Lee, 1987).

The USDA calculates that 1,437 counties, or 46 percent of all U.S. counties, contain groundwater susceptible to contamination from agricultural pesticides or fertilizers (Figure 2-10). An estimated 54 million people living in these counties rely on underground sources of drinking water. The costs or benefits of decontaminating this water are not currently quantifiable. It is likely, however, that contamination in certain regions will persist for many years after remedial actions are taken (Nielsen and Lee, 1987). Several states (including California, Florida, Iowa, New York, and Wisconsin) have developed strategies for dealing with agriculturally induced groundwater contamination. But changes in agricultural practices to reduce groundwater contamination are not widespread. The EPA is also developing a national

Statement of
Ron Rivinius, Secretary-Treasurer
The National Association of Wheat Growers
Before the Subcommittee on Conservation and Forestry
Senate Committee on Agriculture, Nutrition and Forestry
on Water Quality and Agriculture
October 24, 1989

Mr. Chairman and Members of the Subcommittee:

My name is Ron Rivinius, and I am an officer of the National Association of Wheat Growers. My family and I operate a wheat farm in Elgin, North Dakota. I am pleased to address the subject of water quality and agriculture today, and I am also speaking on behalf of the National Cotton Council, the National Corn Growers Association, the American Soybean Association, and the U.S. Rice Producers Legislative Group.

In response to the environmental concerns of farmers and the American public, we have seen that agronomic research and development has been increasingly focused on environmentally sound crop production systems. For example, soil and water conservation concerns led to the development of low till technologies, and widespread adoption of them by farmers during the past decade.

More recently, the scope of environmental concerns relating to agricultural practices has been broadened to include water quality. We have learned that groundwater in certain regions is vulnerable to contamination by some of the fertilizers and pesticides now in use. We must therefore encourage significantly expanded research in order to understand how these necessary nutrients and crop protection products can be used more precisely in order to lessen their environmental impact. Research results must then be translated into management packages that can be demonstrated to farmers, and adapted to specific cropping practices and field conditions.

USDA has outlined a research plan to gather groundwater data to enable its scientists to better understand the impact of agricultural practices on water quality. This very important research should be supported with the additional funding it will require. USDA also proposes to field-test a variety of technological and management options designed to lessen the environmental impact of agricultural chemicals while maintaining profitability, and to sponsor demonstration projects to introduce the techniques to farmers.

Demonstration projects such as these should lead to more institutionalized technical assistance programs that are focused on environmental protection. An effective delivery system to farmers for expanded water quality technical assistance programs must be designed, utilizing the existing SCS, ASCS, Extension and local conservation districts infrastructure.

Several multi-agency water quality projects under USDA's Rural Clean Water Program are already underway, and represent good prototypes for the kinds of environmental projects that should be supported with additional funding. The Oakwood-Poinsett Lakes Rural Clean Water Project in South Dakota is a 10-year, 100,000 acre project which began in 1982. It is a cooperative effort by the ASCS, SCS, Extension Service, local Conservation District, SDSU Water Resources Institute, South Dakota Department of Water and Natural Resources and other SDSU departments. The purpose of the project is to evaluate how agricultural production affects water quality of lakes and aquifers, and to encourage farmers to use practices to prevent groundwater contamination, including conservation tillage and "best management practices" for fertilizer and pesticide applications.

The project demonstrates the effectiveness of voluntary, incentives-based approaches to encourage the adoption of best management practices. The primary incentive for farmers to participate in the project is the provision of technical services which are generally not otherwise available. For example, good management practices for pesticide use involving integrated pest management techniques means that fields must be more intensively scouted for diseases and other pests so that problems can be discovered early and appropriately treated. Many farm operators are not able to scout on the timetable required for an effective IPM program, and must rely on an outside service, if it is available.

Other projects similar to the one in South Dakota should be encouraged in other regions so that farmers can learn from actual practice, and so that a more precise understanding of how good management practices can successfully control non-point source groundwater pollution can be developed. Knowledge in this regard is very limited. Demonstration projects such as the one at Oakwood will also result in information which can be incorporated into the SCS technical guide, so that non-participating farmers can benefit from the practical experience of those who do participate in pilot projects. At present, the ability of agronomists to recommend specific pesticide management procedures with known results in protecting groundwater is very limited. Even though the leaching potential for various pesticide and fertilizer products may be fairly well understood, the process of developing specific approaches for effective use of these products in environmentally sensitive areas is far from complete.

In addition to the need for technology development, the South Dakota project is a good demonstration of the importance of educational outreach as the most fundamental means of making progress on groundwater protection. And the most obvious, and probably the greatest, contamination risks are an essential part of such an education program. Proper handling of pesticides near wellheads, for example, is an important educational message that has been incorporated into the training in South Dakota and which can do a great deal to prevent accidental spills into groundwater from occurring. Proper adjustment of spray equipment and proper disposal of pesticide containers are crucial elements of groundwater protection education, as well.

Federal and state government education programs must be better funded so that farmers can receive meaningful information in a usable format for a specific crop or a specific field on their farm. Every available means of communicating with farmers to encourage use of better techniques should be utilized, from the Extension Service agent and fertilizer dealer to information management systems on the farmer's home computer. The joint Extension Service/EPA Certified Pesticide Applicator Training Program is another important avenue for educating farmers in regard to proper pesticide use, safety precautions and legal requirements. A new training module aimed at groundwater protection has recently been incorporated into the program, and more emphasis should continue to be placed on these issues. As important as the program is for direct outreach to growers, however, it has historically been underfunded.

Individually, more and more farmers are seeking outside expertise from agronomic specialists on improving input efficiency, including fertilizer and pesticide timing and application rates for specific crops and field sites. For example, fertilizer blends and herbicides can be variably applied based on digitized soil maps generated by computers from infrared photos, soil tests, grid maps and USDA soil survey maps. Farmers are finding that such technical services can often provide advice that makes good economic sense. They can maintain yields while lowering their purchased inputs.

And farmers make such information available to each other through "Maximum Economic Yield" clubs and other forms of information exchanges. While more efficient use of inputs means that farmers can improve their economic return, they can, at the same time, minimize the effects of nitrogen fertilizer, pesticides and other inputs on the environment. Expanded technical assistance programs through government agencies would result, we believe, in even more widespread adoption of more efficient farming systems.

Without question, resources directed towards environmental research and the development of an appropriate technology base for efficient agricultural production in environmentally sensitive areas must be increased. Limited funds must be directed towards geographic areas where soil types and groundwater depths indicate vulnerability to contamination. In general, these areas are being identified without the need for new federally-funded well testing programs. Under Clean Water Act responsibilities, States are already in the process of identifying and monitoring areas with "impaired waters", including surface and groundwaters. States are also updating their non-point source assessment reports, which are additional sources of information identifying critical watersheds. There is therefore much greater need for resources to be directed toward programs for preventing pollution problems rather than further identifying them.

We encourage farmers to have their wells tested if they have reason to believe that their wells may be contaminated with chemical or bacterial agents. Well testing is usually available through county health departments or other sources. However, we do not believe that a federally mandated program of individual well-testing is the key to a meaningful groundwater protection strategy in agriculture. We oppose mandating well-testing or legislating voluntary well-testing for producers. The critical need is for technical assistance and education to prevent contamination and to address any problems that might exist.

We concur with the findings of a recent Economic Research Service study on groundwater that: "Farmer education, backed by well documented research, will be a major and cost-effective strategy in preventing or minimizing groundwater contamination, as opposed to the monitoring and remedial action approach, the costs of which are potentially significant and would largely fall into the rural sector".

In conclusion, we urge the Congress to adopt legislation authorizing and funding new cooperative efforts through Federal, state and local agencies to significantly strengthen existing programs or create new ones for the prevention and abatement of water quality pollution from agricultural sources. The programs should be aimed at expanded research, as well as accelerated technical, educational and financial assistance at the local level to promote development and implementation of best management practices.

Water quality best management practices are those management practices and systems that are likely to reduce the chances of water quality contamination for a wide range of conditions. Some of these practices and systems have been identified by soil and water scientists, and can be readily adapted to certain farming operations, while others must be developed through research and field-testing to determine their effectiveness, as well as technical and economic feasibility.

In short, the cooperative approach which has been effectively taken for decades in implementing conservation and erosion control programs on cropland should be utilized to address water quality protection. Without linking water quality initiatives in any way to commodity programs, practical expertise should be made available to the farmer within the delivery system that is familiar and easily accessible to him.

Other initiatives that have proven water quality protection benefits and which should continue to be supported include the Conservation Reserve Program. USDA has concluded that the CRP has "significantly reduced the quantity of sediments, nutrients and pesticides entering this Nation's waters". The Congress should give consideration to extending CRP contracts when they expire, at the producer's option, as well as protecting the farmer's production base without requiring him to raise a crop for at least five years after contract expiration.

Thank you very much, Mr. Chairman, for your consideration of our views. I look forward to answering any questions you may have.

TESTIMONY OF

George W. Wallingford, PhD
Potash & Phosphate Institute

before the

Senate Committee on Agriculture,
Nutrition, and Forestry
Subcommittee on Conservation and Forestry

October 24, 1989

THE FERTILIZER INSTITUTE, 501 Second Street, N.E., Washington, D.C. 20002 (202) 675-8250

Distinguished Chairman, members of the Subcommittee, my name is George Wallingford, East Central Director of the Potash & Phosphate Institute (PPI). I appear hear today on behalf of The Fertilizer Institute (TFI). TFI and PPI are sister organizations representing the fertilizer industry domestically and around the world. PPI is a research arm for the industry while TFI focuses on legislative affairs. On behalf of PPI, I thank you for the privilege to testify this morning on preserving and protecting one of our nation's most important natural resources, groundwater.

Both TFI and PPI commend you Mr. Chairman and the subcommittee for your strong interest in addressing the groundwater contamination issue. For more than 50 years, PPI has used its research base and education programs to direct agriculture producers to use fertilizer more efficiently, both in terms of economics and environmental protection. PPI and its sister organization, the Foundation of Agronomic Research (FAR), provide industry direction and support in identifying critical research needs while implementing education programs which help assure the economic stability of farmers and our nation's continued strong capability for sustained food and fiber production.

Since 1980, PPI and the Foundation for Agronomic Research have funded 250 agronomic and environmental research projects in 37 states exceeding $3.5 million. Like this subcommittee, the fertilizer industry too are an active partner in agriculture research, having a keen interest in the efficient and safe use of agricultural inputs, while at the same time preserving and making the best use of our nation's quality groundwater.

The Committee is well aware of the vital role groundwater plays in our society's existence. Groundwater currently supplies drinking water for 50 percent of this nation's population, or 117 million Americans. It provides 35 percent of the drinking water supply used in urban areas and 95 percent of the supply in rural areas[1]. Not only is groundwater important for the drinking and irrigation needs of farm states, but is just as important for urban population needs and industrial uses.

Once thought of as a pristine and abundant natural resource, the quality and quantity of our nation's groundwater supply is today being questioned, and rightfully so. Media headlines describing leaking underground storage tanks, leaks from hazardous waste landfills and septic tanks, as well as suspected agriculture chemical and nutrient runoff, have made us aware that ground and surface water can and has been contaminated in certain areas. I share the committee's concerns about these problems and on the question of water quality in general.

1/ Testimony of Environmental Protection Agency to Senate Environment and Public Works Committee, Subcommittee on Superfund, Ocean and Water Protection, August 1, 1989.

However, the vast majority of our underground drinking water is safe. Recently, representatives from the Environmental Protection Agency, the U.S. Geological Service and USDA, before a joint hearing of two House subcommittees, testified that "there is no national crisis of groundwater contamination at this time." To date, groundwater contamination has been found to be site specific. Chemical spills, leakage of hazardous materials from storage tanks and waste sewage runoff have caused serious problems in a number of localities by contaminating groundwater beyond safe drinking levels.

For example, in my home state of Ohio a recent survey conducted by The Water Quality Laboratory of Heidelberg College showed no widespread nitrate contamination of wells with nitrate. Of the over 14,000 wells sampled, only 2.7% had nitrate levels exceeding U.S. EPA water quality standards. The survey also correlated nitrate levels with several factors in an attempt to understand the causes of contamination. The lowest levels of contamination were found in Northwest Ohio which contains the state's most intensive agriculture. Higher levels were found in forested areas of Southeast Ohio which has little agriculture. Factors such as the age and depth of the well had a much greater affect on nitrate contamination than did the well's proximity to cropland.

RESEARCH

Research will continue to play a key role in identifying, monitoring and correcting problem areas. And further research is needed to assist industry, agriculture and regulating agencies to become more proactive, focusing on prevention of groundwater contamination rather than on clean-up.

But let us not overlook the research that has already been done. Industry, scientific bodies, universities, individual producers, and federal and state agencies have conducted ground and surface water research in this country for more than a century. A huge body of knowledge and data already exists on the subject. It is critical that we do not ignore earlier research and waste time and resources duplicating programs and "re-inventing the wheel." Scientists in the Agriculture Research Service, Soil Conservation Service and other research organizations have the responsibility to not only generate new data, but to integrate existing knowledge to improve our understanding of how agriculture production systems and how those systems effect water, soil and the environment.

Duplicating existing programs or creating similar programs already in existence, would be unproductive and do nothing to prepare us for the serious site specific groundwater pollution problems we face today and may face in the future. I commend the committee for its leadership in directing that further research education, not regulation, is the key to understanding and preventing groundwater contamination. We must build on the strong science and technical information base already in existence, taking the research we already have to prepare for tomorrow's contamination prevention needs.

Specific research objectives should:

- Determine the extent and seriousness of potential agricultural contributions to groundwater contamination;
- Develop improved farm and ranch production systems using Best Management Practices to maintain and improve water quality, without sacrificing profitability;
- Develop less costly groundwater sampling and monitoring techniques;
- Build on the base of information already available.

Furthermore, I believe additional funding is critical to this effort. Scientists in our Land Grant Universities and Agricultural Research Service continue to do a superb job of developing new technologies allowing food to be produced at a lower unit cost at less environmental risk.

Whatever type of research initiatives this committee chooses it is important that legislative proposals are followed with needed appropriations at realistic funding levels.

EDUCATION AND TECHNICAL ASSISTANCE

The transfer of technology to the farmer is too slow and must be improved. Technologies are still not being used today that years ago were proven to be profitable and environmentally safe. Slowness of adoption is do partly to the caution farmers naturally show when evaluating new technology. Farmers are smart, cautious businessmen who do not change their management until convincing evidence is presented to them.

But the primary reason for the slowness of adoption of new technology is shortcomings in our education system. At a time when it has never been more important for farmers to have access to new information, our education system is simply not up to the task. This is not due to lack of will or knowledge but rather a lack of money to implement effective producer and consumer educational programming.

The Extension Service has been devastated by budget cuts over the last several decades. From personal experience, I know that the number of state crop production specialists has fallen dramatically in the last decade as vacancies caused by retirements have gone unfilled. This has prevented the Extension Service from fulfilling its educational mission -- a mission I feel it is still quite capable of carrying out.

For example, there are many aspects of Best Management Practices or BMP's developed by our Land Grant Universities that do not successfully get transferred to the farm. These BMP's do not require massive changes in agriculture -- which is favored by some low-input advocates. They are management practices which can easily be adapted with a minimum of capital outlay. What is lacking is convincing information presented in ways a farmer can understand and use. The Extension Service is expert at using how-to brochures, farmer meetings and the print and broadcast media to get the message out. What we need to do is give the Extension Service the resources it needs, then step back and let it work.

Some examples of Best Management Practices developed by ARS and Land Grant University scientists include:

- improved nitrogen application timing which reduces nitrogen leaching;
- improved chemical testing of soils to provide more accurate fertilizer recommendations which improves yields and increases the efficiency of other applied inputs;
- increased use of crop rotations which increases the yields of all crops in the rotation and can reduce the need for applied nitrogen;
- conservation tillage techniques which dramatically reduce the major source of agriculture pollution, which is soil erosion.

It should be noted that these same Best Management Practices are now touted by low-input advocates as being "new ideas" arising from the alternative agriculture movement. In reality, agricultural scientists for decades have been investigating these and many other farming improvements which reduce pollution. increase yields and improve farmer profits. Many farmers are now using these same BMPs in their conventional farming systems. The challenge is to develop improved education programs which convince more farmers to use them.

DATA COLLECTION

Data collection is an important part of understanding groundwater aquifer boundaries, aquifer recharge cycles, potential groundwater yields and whether or not an aquifer is connected to other aquifers, streams or rivers. Accurate information is needed not only on what is happening naturally below the surface, but also how human and natural activities on the surface affect contamination trends. The lack accurate information hampers local governments, agriculture producers and others in making important land use decisions.

Again, we must not discount the information already supplied by industry and agriculture through voluntary programs, current regulations and "community right-to-know laws." For example Mr.

Chairman, in your home state of Georgia, the Georgia Department of Agriculture annually reports specific amounts of fertilizer use on a per county basis. In the home state of this subcommittee's ranking member, The University of Missouri-Columbia Agriculture Experiment Station also reports fertilizer use on a county by county basis, as do the majority of states in the country. Additionally, TFI, in cooperation with TVA, has provided financial and technical assistance to 26 states in acquiring computer software that contributes to uniform fertilizer tonnage reporting in those states.

In short, much of the data asked for by those investigating groundwater contamination is readily available from various state agencies. As described, fertilizer use is currently compiled at the county level by state agencies and is readily available to the public. I believe the current system works well and provides sufficient accounting of fertilizer use.

More detailed data collection from the producer would likely require some form of individual farm accounting and regulation. Besides being of little value to water quality protection, this would place an additional expense and paperwork burden on farmers. It is unnecessary and unproductive for producers to have to file the equivalent of an environmental impact statement every time they plant or harvest a crop. Keep in mind those who live "off the land" also live "on the land." Farmers were good stewards of the land long before the cliche was coined.

Instead, data collection should focus on further groundwater testing and monitoring. Granted, drilling test wells is costly and time consuming and that groundwater monitoring is expensive and often technically difficult. However, it is this type of research that nets the most practical and useable knowledge in evaluating the extent of contamination in public and private drinking water wells.

REGULATION

As I mentioned earlier, further research and education not regulation, is the key to understanding and preventing groundwater contamination. Compared to improved education and research programs, regulation offers little hope of improving water quality.

Already, agriculture and rural communities are strapped with expensive and time consuming regulations. The major regulating body, EPA, said it best in its report entitled "Municipalities, Small Business, and Agriculture: The Challenge of Meeting Environmental Responsibilities", published September 1988. The report stated that 85 major regulations concerning agriculture and rural communities are either going into effect now or planned for the near future. The regulations range from "rural fugitive dust" to pesticides, ozone and engine emissions.

EPA estimates residents of communities of 2,500 or smaller will pay $170 more per person for essential services than urban residents as a result of environmental regulations. The regulatory agency estimated that small town agribusinesses likely would have to contribute up to $10,000 more than urban businesses to comply with upcoming regulations. And EPA concluded that our financially strapped farmers and cattle producers might well go out of business as a result of having to pay the cost of further regulation.

As you can see Mr. Chairman, excessive regulation becomes nothing more than a "pay up or shut down" regulatory attitude. I trust this committee will keep this in mind as it progresses with this important research effort.

In conclusion, Mr. Chairman, I'd like to add that American farmers produce the safest, cheapest and most abundant food supply in the world. In 1985 American cunsumers spent approximately 15 percent of their income in food. Today that figure is near 11 percent. Safe and abundant groundwater supplies no doubt have contributed richly to this nation's consumer prosperity.

Farmers realize that the same water they irrigate with usually comes from the same aquifer supplying their family's drinking water. Agriculture producers have traditionally been aware that groundwater is an important and irreplaceable natural resource -- as is our soil, environment and the end product, our food supply.

Nevertheless, the challenges facing agriculture to protect water quality are difficult ones that need addressed, pursued and effectively managed.

I believe that groundwater policy should be based on fact and solid scientific research, not media hype and special interest misinformation. By improving research programs at Land Grant Universities and the Agriculture Research Service, we can generate needed information showing farmers how to increase production, lower costs and protect water quality.

In addition, by strengthening Cooperative Extension Service education programming, we can improve the lines of communication between the scientific community and agricultural producers. By convincing farmers to adopt known Best Management Practices, tremendous progress can be made towards achieving water quality protection.

Mr. Chairman, I am submitting for the record a more detailed analysis and explanation of Best Management Practices published by the Potash & Phosphate Institute. Also, I have included for the record copies of both the Georgia and Missouri State Fertilizer and Liming Materials Tonnage Reports giving fertilizer use data on a county by county basis in those states.

Again, thank you Mr. Chairman, and members of the subcommittee for your invitation to be with you today. I would be pleased to respond to any questions your or other members might have at the appropriate time.

Georgia Department of Agriculture

Thomas T. Irvin, Commissioner

Fertilizer and Liming Materials Tonnage Report

JULY 1988 —JUNE 1989

LIMING MATERIALS SUMMARY
July, 1988 thru June, 1989

TOTAL TONS:	769,846
Dolomitic	693,067
Calcitic	76,779
Dry	719,456
Liquid	50,390
Farm	767,712
Non-Farm	2,134

FERTILIER SUMMARY
July, 1988 thru June, 1989

TOTAL TONS:	1,555,948
Mixed Grades	846,927
Single Nutrient Materials	508,609
N-452,346 P- 14,761 K- 41,502	
Secondary/Micro/ Organic/Misc.	200,412

SUMMARY OF TOTAL FERTILIZER & PLANT NUTRIENTS
GEORGIA
JULY, 88 THRU JUNE, 89

COUNTY	GRAND TOTAL	TOTAL SINGLE NUT.	TOTAL MULTI NUT.	ALL OTHERS	MULTI-NUT. GRADES TOTAL N	TOTAL P205	TOTAL K20	ALL FERTILIZERS TOTAL N	TOTAL P205	TOTAL K20
APPLING	14,436	6,878	7,497	62	557	763	1,144	2,100	853	1,801
ATKINSON	4,789	1,417	3,049	323	231	271	598	668	272	611
BACON	6,827	2,736	4,059	32	314	429	811	1,128	456	900
BAKER	8,995	3,009	4,675	1,311	315	596	645	1,063	623	853
BALDWIN	1,140	302	776	63	123	57	107	216	59	120
BANKS	1,175	482	693	0	60	105	80	165	172	80
BARROWS	2,763	1,161	1,573	29	159	160	188	534	161	202
BARTOW	8,197	3,319	4,562	317	470	572	553	1,424	580	797
BEN HILL	13,399	5,190	5,954	2,255	350	790	936	1,969	824	1,274
BERRIAN	24,283	6,810	13,580	3,893	1,044	1,518	2,579	3,340	1,551	2,621
BIBB	5,878	1,636	3,704	538	463	421	496	872	425	538
BLECKLEY	10,336	2,802	6,573	960	570	902	1,229	1,430	902	1,248
BRANTLEY	1,813	785	990	38	93	192	117	190	532	118
BROOKS	21,023	6,607	12,450	1,966	1,135	1,559	2,044	2,712	1,572	2,181
BRYAN	1,112	434	651	27	34	79	98	123	79	147
BULLOCH	49,941	15,639	23,896	10,406	1,930	2,951	4,227	5,772	3,207	5,570
BURKE	26,118	11,685	13,515	918	1,181	1,769	2,587	3,412	2,100	3,673
BUTTS	2,166	289	1,875	2	338	130	196	412	131	236
CALHOUN	17,568	5,846	9,580	2,142	641	1,646	1,443	2,075	1,740	1,461
CAMDEN	2,455	117	2,321	18	421	169	52	446	169	52
CANDLER	11,550	2,771	8,391	388	602	789	1,326	1,302	866	1,391
CARROLL	7,149	1,578	5,490	81	600	521	543	1,119	524	569
CATOOSA	399	173	219	7	29	32	25	86	32	39
CHARLTON	319	126	144	49	10	11	26	11	15	48
CHATHAM	4,229	1,350	2,509	370	297	206	257	1,087	209	278
CHATTAHOOCHEE	234	46	188	1	22	17	17	35	17	17
CHATTOOGA	1,385	705	664	16	68	77	102	300	77	102
CHEROKEE	1,674	204	1,392	79	163	150	168	230	151	171
CLARKE	4,499	1,005	2,997	496	347	547	269	637	550	279
CLAY	2,096	1,027	830	239	73	102	130	331	102	130
CLAYTON	1,358	60	1,058	240	139	89	113	158	90	114
CLINCH	6,586	1,360	5,224	2	756	1,980	148	945	2,009	148
COBB	5,866	190	4,339	1,337	508	349	482	583	353	490
COFFEE	49,048	15,126	20,693	13,229	1,274	2,242	3,540	4,840	2,400	4,948
COLQUITT	45,982	14,125	28,221	3,636	2,180	3,408	4,797	5,704	3,447	5,113
COLUMBIA	1,263	354	814	95	96	60	139	204	61	151
COOK	19,031	4,249	8,984	5,799	593	1,043	1,694	1,634	1,083	1,795
COWETA	3,314	1,308	1,928	78	214	203	224	526	205	457
CRAWFORD	2,487	1,347	1,125	14	135	162	229	445	165	242
CRISP	20,114	6,747	11,667	1,701	800	1,451	2,328	2,496	1,461	2,380
DADE	359	102	239	18	32	23	24	59	23	38
DAWSON	101	30	71	0	5	7	11	15	7	11
DECATUR	51,079	19,630	19,569	11,880	1,321	3,342	2,402	5,356	3,923	4,417
DE KALB	4,905	147	3,505	1,253	578	248	309	623	254	315
DODGE	7,851	3,231	4,236	383	328	503	786	1,303	508	818
DOOLY	35,264	7,624	24,467	3,173	1,639	3,089	3,982	3,927	3,096	3,989
DOUGHERTY	17,354	6,084	6,009	5,261	504	692	1,273	1,864	700	1,374
DOUGLAS	545	53	358	135	58	29	30	76	29	31
EARLY	41,692	11,768	22,022	7,902	2,057	3,790	3,774	5,320	3,906	3,799
ECHOLS	10,910	3,311	7,442	157	523	432	1,120	1,426	452	1,140
EFFINGHAM	5,958	2,461	3,302	196	216	342	476	908	343	490
ELBERT	4,604	1,591	3,010	3	418	309	519	919	309	578

SUMMARY OF TOTAL FERTILIZER & PLANT NUTRIENTS
GEORGIA
JULY, 88 THRU JUNE, 89

COUNTY	GRAND TOTAL	TOTAL SINGLE NUT.	TOTAL MULTI NUT.	ALL OTHERS	MULTI-NUT. GRADES TOTAL N	MULTI-NUT. GRADES TOTAL P205	MULTI-NUT. GRADES TOTAL K20	ALL FERTILIZERS TOTAL N	ALL FERTILIZERS TOTAL P205	ALL FERTILIZERS TOTAL K20
EMANUEL	13,757	5,358	7,706	692	553	1,006	1.276	1.859	1,054	1.336
EVANS	6,745	2,303	3,548	895	336	421	743	821	450	952
FANNIN	1,112	160	945	7	94	114	119	147	114	119
FAYETTE	1,980	236	1,634	110	184	172	207	228	173	244
FLOYD	3,275	998	2,113	164	258	250	357	579	250	366
FORSYTH	2,813	902	1,841	69	204	192	229	485	193	239
FRANKLIN	4,350	1,707	2,640	3	350	264	389	901	264	406
FULTON	22,820	7,150	6,590	9,080	992	474	571	1,504	485	3,935
GILMER	561	186	368	7	31	39	47	93	39	47
GLASCOCK	1,047	324	678	45	29	73	138	89	83	182
GLYNN	8,437	391	806	7,240	92	53	110	102	55	292
GORDON	6,195	2.389	3,751	55	382	475	563	1.171	522	706
GRADY	31,524	14,495	14,295	2,735	1.435	2,408	1.872	5.032	2.503	2.515
GREENE	1,512	497	1,013	3	130	76	137	278	77	137
GWINNETT	9,383	1,330	7,161	892	915	656	791	1,317	662	839
HABERSHAM	1,123	291	784	47	87	50	99	157	50	100
HALL	4,367	965	3,306	97	313	306	400	613	307	413
HANCOCK	1,410	595	815	0	83	67	117	243	67	118
HARALSON	565	359	203	2	21	24	28	143	24	29
HARRIS	2,670	1,719	952	0	88	96	134	607	96	247
HART	4,513	1,521	2,958	34	396	284	426	841	284	473
HEARD	359	287	71	0	8	14	8	61	14	49
HENRY	3,285	1,380	1,829	75	267	181	220	655	181	315
HOUSTON	14,641	6,093	7,929	619	649	816	1,034	2,126	860	1,067
IRWIN	25,082	7,642	9,166	8,275	607	1,237	1,486	2,792	1,331	1,811
JACKSON	1,295	319	957	19	96	92	110	201	92	113
JASPER	312	143	165	4	31	8	24	71	8	24
JEFF DAVIS	7,427	1,906	5,470	51	336	517	1,154	896	517	1.197
JEFFERSON	24,144	9,526	14,145	473	618	1,328	2.526	3,223	1.410	2,807
JENKINS	15,069	5,943	7,478	1,648	604	981	1.497	2.104	975	1,650
JOHNSON	10,876	3,839	6,384	653	426	603	1,136	1.540	603	1.157
JONES	1,310	565	745	0	77	78	118	253	79	121
LAMAR	3,466	1,686	1,779	0	211	261	384	728	275	410
LANIER	3,534	1,294	2,240	0	116	215	344	444	215	503
LAURENS	23,203	8,534	11,963	2,706	1.072	1,526	2,396	3,342	1.579	2,469
LEE	26,992	8,880	17,453	659	1,236	2,711	3,392	3.328	2.717	3.505
LIBERTY	730	91	588	50	52	52	55	76	53	55
LINCOLN	548	97	451	0	51	26	45	82	26	45
LONG	321	160	155	7	16	11	18	42	11	52
LOWNDES	10,634	2,558	7,921	155	685	690	1,302	1,417	692	1.380
LUMPKIN	391	120	260	11	26	25	29	62	25	30
MC DUFFIE	3,402	1,108	2,213	81	282	231	373	625	231	405
MC INTOSH	64	23	18	23	2	1	2	10	2	3
MACON	21,441	7,505	8,487	5,450	884	1,386	1,588	2.669	1.447	1,773
MADISON	2,718	1,124	1,589	5	203	160	233	541	160	252
MARION	2,196	390	1,753	53	144	176	275	249	176	298
MERIWETHER	6,528	3,748	2,780	0	287	329	379	1,478	335	479
MILLER	30,158	11,063	15,435	3,660	1,075	1,683	2,364	4,257	1,760	2,488
MITCHELL	68,639	22,973	30,198	15,469	2,617	3,523	5,043	8,501	3,686	5.498
MONROE	2,076	851	1,199	26	152	139	229	410	139	229
MONTGOMERY	6,503	1,656	4,371	477	250	395	646	732	395	646
MORGAN	9,716	2,484	6,622	610	959	680	754	1,705	686	775

SUMMARY OF TOTAL FERTILIZER & PLANT NUTRIENTS
GEORGIA
JULY, 88 THRU JUNE, 89

COUNTY	GRAND TOTAL	TOTAL SINGLE NUT.	TOTAL MULTI NUT.	ALL OTHERS	MULTI-NUT. GRADES TOTAL N	MULTI-NUT. GRADES TOTAL P205	MULTI-NUT. GRADES TOTAL K20	ALL FERTILIZERS TOTAL N	ALL FERTILIZERS TOTAL P205	ALL FERTILIZERS TOTAL K20
MURRAY	498	65	430	4	48	82	84	71	82	86
MUSCOGEE	2,110	103	1,658	350	254	132	201	285	134	205
NEWTON	7,997	2,714	5,205	78	725	763	658	1,477	769	690
OCONEE	2,823	1,201	1,591	31	170	137	254	498	137	286
OGLETHORPE	552	325	227	0	25	18	32	128	18	39
PAULDING	786	235	542	10	53	57	59	132	57	60
PEACH	10,287	3,732	6,384	172	883	882	1.277	1,731	920	1.453
PICKENS	522	56	462	4	45	50	82	64	50	82
PIERCE	12,494	4,080	6.319	2.095	442	578	1,137	1.534	593	1,267
PIKE	888	382	504	1	65	70	92	182	71	113
POLK	3,245	1,059	2,174	12	237	250	273	586	250	280
PULASKI	17,617	4.817	11,252	1,548	539	1,296	1,745	2,075	1.297	1,835
PUTNAM	5,352	1,536	3,815	1	412	258	553	907	258	580
QUITMAN	255	47	208	0	22	30	41	36	30	41
RABUN	577	98	477	1	53	53	58	85	53	59
RANDOLPH	20,831	9,626	10,552	654	634	1,515	1,429	3,312	1.747	1,516
RICHMOND	5,588	2,874	1,469	1,246	191	134	152	661	196	276
ROCKDALE	1,023	112	772	140	109	66	85	143	67	86
SCHLEY	5,002	1,855	2,799	348	197	280	432	609	282	454
SCREVEN	20,751	9,443	7,872	3,436	595	1,142	1,414	2,976	1,251	2.485
SEMINOLE	44,379	10,212	27,335	6.833	2,911	2,920	4,290	5,971	3.609	4.607
SPALDING	6,174	2,823	3.322	28	423	398	462	1,164	457	675
STEPHENS	1,623	508	1,067	48	115	97	122	274	97	125
STEWART	8,615	2.022	3,813	2,780	166	449	551	705	454	638
SUMTER	29,716	11,059	15,982	2,675	1,065	1,944	2,238	4,132	2.030	2,419
TALBOT	147	39	108	0	14	8	14	22	8	22
TALIAFERRO	342	94	248	0	28	13	27	55	13	33
TATTNALL	13,174	3,706	9,204	264	640	874	1.287	1,689	876	1,379
TAYLOR	5,693	1,823	3,548	322	435	397	718	961	397	725
TELFAIR	10,373	3,840	5,554	979	349	613	931	1,515	627	1.103
TERRELL	21,473	8,718	10,850	1,905	605	1,949	1.407	2,809	2,119	1.761
THOMAS	31,085	11,826	16,763	2,495	1,576	2,054	2.805	4,570	2,091	3,197
TIFT	33,906	8,348	21,233	4,325	1,548	2,161	3,425	3,954	2.213	3,550
TOOMBS	18,021	4,145	12,822	1,053	920	1,278	2,312	2,120	1,286	2.332
TOWNS	362	90	268	4	26	29	30	56	29	31
TREUTLEN	478	420	58	0	5	11	5	102	23	45
TROUP	4,766	922	3,760	84	404	379	524	687	394	537
TURNER	30,349	6,899	15,020	8,430	1,388	1,850	2,710	3,290	1.906	3.087
TWIGGS	566	213	353	0	16	38	60	75	38	61
UNION	3,276	553	2,716	6	294	276	379	457	279	390
UPSON	2,048	1,092	915	40	100	105	147	453	106	149
WALKER	3,450	672	2,622	156	286	381	387	491	396	406
WALTON	2,970	1,427	1,531	12	184	118	200	627	118	218
WARE	6,985	2,498	4,374	113	378	392	806	1,098	397	663
WARREN	4,775	2,874	1,900	0	162	156	375	944	156	495
WASHINGTON	14,205	6,244	7,801	160	429	749	1.314	2,102	789	1,380
WAYNE	10,931	2,666	8,053	211	676	620	998	1,270	623	1,204
WEBSTER	5,981	1,911	2,761	1,309	158	368	391	593	408	435
WHEELER	5,111	2,206	2,716	189	230	376	631	857	376	709
WHITE	832	187	643	2	60	63	73	121	63	74
WHITFIELD	2,617	727	1,670	220	201	190	212	456	191	217
WILCOX	16,794	5,291	8,733	2,770	584	1,019	1,545	3,098	1,033	1,708

SUMMARY OF TOTAL FERTILIZER & PLANT NUTRIENTS
GEORGIA
JULY, 88 THRU JUNE, 89

					MULTI-NUT. GRADES			ALL FERTILIZERS		
COUNTY	GRAND TOTAL	TOTAL SINGLE NUT.	TOTAL MULTI NUT.	ALL OTHERS*	TOTAL N	TOTAL P205	TOTAL K20	TOTAL N	TOTAL P205	TOTAL K20
WILKES	5,353	1,547	3,773	33	437	313	456	934	313	495
WILKINSON	711	279	432	0	32	52	69	115	52	74
WORTH	36,286	10,599	21,226	4,460	1,479	2,744	3,558	4,400	2,778	3,724
** UNKNOWN **	2,322	879	42	1,401	6	11	6	288	11	6
Totals	1,555,948	508,609	846,927	200,412	72,094	102,106	135,041	206,697	106,627	156,413

* INCLUDES SEC/MICRO, ORGANIC, & MISC. MATERIALS.

UNIVERSITY OF MISSOURI-COLUMBIA

Agricultural Experiment Station

MISSOURI FERTILIZER TONNAGE REPORT, 1988-89

DRY MIXED FERTILIZERS

GRADES	BAGGED FERTILIZER FALL	BAGGED FERTILIZER SPRING	BULK MANUFACTURED FALL	BULK MANUFACTURED SPRING
0-18-36	---	---	257	738
5-20-35	35	133	572	1,624
6-18-36	---	---	244	525
6-24-24	1,911	6,159	1,675	4,600
8-32-16	305	198	---	155
9-23-30	---	---	392	350
10-6-4	498	1,042	---	---
12-12-12	1,590	3,965	---	93
13-13-13	3,085	7,527	1,902	3,387
17-17-17	---	6	176	336
20-10-10	263	853	108	732
25-3-3	446	1,286	1,085	443
27-3-3	510	1,550	---	2,203
Misc.	5,914	8,940	9,257	18,125
TOTAL	14,557	31,659	15,668	33,311

FERTILIZER MATERIALS

NITROGEN MATERIALS	FALL	SPRING
Ammonium Sulfate	2,590*	11,387*
Amm. Thiosulfate	332	2,613
N. Solutions(26-32%)	65,817	146,052
Ammonium Nitrate	61,280*	116,880*
Urea	95,777*	175,260*
Anhydrous Ammonia	18,621	78,258
Other	3,726	13,570
TOTAL	248,143	544,020

PHOSPHORUS MATERIALS	FALL	SPRING
Conc. Superphosphate	23,190*	33,548*
Phosphoric Acid	339	3,035
Rock Phosphate	178	108
Other	60	64
TOTAL	23,767	36,755

POTASH MATERIALS	FALL	SPRING
Muriate of Potash	166,719	207,470
Other	5,673	8,658
TOTAL	172,392	216,128

MISC. MATERIALS	FALL	SPRING
Organics	4,672	6,000
Other	2,645	5,347
TOTAL	7,317	11,347
TOTAL MATERIALS	451,619	808,250

*Includes tonnage reported as materials but blended prior to application.

LIQUID MIXED FERTILIZERS

GRADES	FALL	SPRING
2-6-12	376	418
2-6-32	170	546
3-9-27	4,452	14,751
3-10-10	27	1,080
3-10-30	23	314
3-18-18	829	1,907
4-10-10	505	266
4-12-24	8	386
5-5-10	---	617
6-6-12	496	656
7-23-5	---	623
9-18-9	321	636
10-5-10	---	553
10-20-10	12	747
10-30-0	2,381	8,367
10-34-0	1,406	2,518
12-6-6	8	614
12-12-12	813	309
14-4-7	350	32
15-4-5	---	361
Misc.	6,495	14,797
TOTAL	18,672	50,498

DRY MIXED FERTILIZERS

AMMONIUM PHOSPHATES

	BAGGED FERTILIZER FALL	BAGGED FERTILIZER SPRING	BULK MANUFACTURED FALL	BULK MANUFACTURED SPRING
11-52-0	7	8	11,851*	10,159*
18-46-0	84	3	122,984*	118,052*
TOTAL	91	11	134,835	128,211

	FALL	SPRING
TOTAL MIXED FERTILIZER	183,823	243,690
TOTAL ALL FERTILIZER	635,442	1,051,940
GRAND TOTAL	1,687,382	

PRINCIPAL BLENDING MATERIALS

(Approximate Tons Used in Blends)

	FALL	SPRING
Ammonium Nitrate	49,024	93,504
Urea	76,622	140,208
Ammonium Phosphates	107,868	102,569
Concentrated Phosphates	18,552	26,838
Muriate of Potash	133,375	165,976

RECENT FERTILIZER SALES TRENDS IN MISSOURI

% OF TOTAL SALES

	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
BAGGED FERTILIZERS								
Mixtures	4.3	4.0	3.5	3.8	3.5	3.1	3.0	3.1
Materials	1.3	1.2	0.9	0.6	0.8	1.1	0.7	0.8
TOTALS	5.6	5.2	4.4	4.4	4.3	4.2	3.7	3.9
BULK DRY FERTILIZERS								
Blends	47.5	47.9	51.0	47.8	49.1	54.0	55.5	51.6
Mfg'd. Mixtures	3.7	3.7	4.2	3.4	3.7	2.7	2.5	10.7
Dir. Appl. Material	14.4	16.1	15.1	14.0	15.1	14.6	15.5	11.0
TOTALS	65.6	67.7	70.3	65.2	67.9	71.3	73.5	73.3
LIQUID FERTILIZERS								
Mixtures	11.5	12.0	10.6	10.7	8.2	6.0	5.0	4.1
Nitrogen Solutions	10.4	9.5	10.0	12.1	12.6	12.5	12.8	13.0
Anhydrous Ammonia	6.9	5.5	4.7	7.6	7.0	6.0	5.5	5.7
TOTALS	28.8	27.0	25.3	30.4	27.8	24.5	23.3	22.8
TOTAL TONS	1,500,532	1,420,420	1,568,742	1,528,261	1,478,308	1,450,200	1,571,166	1,687,382

APPROXIMATE TONNAGE BY COUNTIES OF FERTILIZERS SHIPPED FOR USE IN MISSOURI, JULY 1 THRU DECEMBER 31, 1988.

COUNTIES	TOTAL ALL FERTILIZERS	MIXED FERTILIZER				FERTILIZER MATERIALS								PLANT FOOD		
		BAGGED	BULK DRY	LIQUID	TOTAL MIXED FERTILIZER	POTASSIC MATERIALS	PHOSPHATIC MATERIALS	AMMONIUM PHOSPHATES	AMMONIUM NITRATE	UREA	NITROGEN SOLUTIONS	ANHYDROUS AMMONIA	MISC. MATERIALS	NITROGEN	AVAILABLE P_2O_5	SOLUBLE K_2O
Adair	2636	36	32	---	68	644	245	812	52	443	292	80	---	531	495	400
Andrew	3634	5	26	60	91	1094	379	585	112	862	302	184	25	779	455	671
Atchison	11136	2	678	460	1140	1790	126	1972	---	373	4363	647	725	2308	1312	1314
Audrain	19681	16	20	117	153	5341	2379	5302	2	4174	1387	888	55	3916	3637	3082
Barry	4856	31	121	---	152	1232	93	905	2434	---	---	40	---	1033	484	770
Barton	12990	50	303	43	396	3937	145	4127	867	2086	876	289	287	2526	2076	2367
Bates	11147	6	118	308	432	3263	140	4171	1456	1260	86	160	179	1988	2057	2024
Benton	2819	---	---	---	---	1433	117	714	99	410	---	20	26	372	382	849
Bollinger	625	1	25	9	35	157	**	192	---	243	---	---	---	148	92	104
Boone	10837	176	---	750	926	3100	774	2037	12	1725	1701	547	15	2182	1489	1987
Buchanan	4213	121	25	475	621	1049	199	434	143	392	1165	159	51	835	380	727
Butler	7282	21	---	---	21	1163	649	425	56	4604	171	102	91	2364	495	699
Caldwell	6077	8	---	147	155	1365	327	1444	2150	500	55	81	---	1309	833	855
Callaway	4468	58	---	34	92	1301	151	1737	53	801	300	25	8	794	897	797
Camden	27	27	---	---	27	---	---	---	---	---	---	---	---	7	1	2
Cape Girardeau	4288	474	354	12	840	1136	399	646	307	616	179	140	5	758	629	844
Carroll	7357	120	---	163	283	1928	518	2399	24	1435	384	379	7	1505	1430	1176
Carter	1	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---
Cass	9047	150	758	218	1126	2653	40	3013	1020	497	465	180	53	1399	1697	1870
Cedar	3344	84	---	---	84	1163	51	970	684	391	---	---	1	597	400	708
Chariton	10797	61	55	1487	1603	2938	706	2751	---	1430	941	399	29	1788	1847	2120
Christian	2131	25	---	---	25	727	142	451	692	95	---	---	---	362	277	435
Clark	14119	32	196	512	740	2107	882	816	194	916	8045	417	2	3584	991	1367
Clay	1064	220	---	---	220	45	1	91	635	20	4	22	26	305	51	37
Clinton	3686	19	---	---	19	497	108	1234	937	687	51	99	54	960	619	302
Cole	2614	269	24	---	293	687	48	675	301	467	72	61	10	542	380	458
Cooper	8452	19	76	---	95	2980	328	2504	451	1330	445	317	4	1607	1324	1801
Crawford	135	9	126	---	135	---	---	---	---	---	---	---	---	29	19	19
Dade	9779	154	374	---	528	3719	98	1928	2749	190	159	41	367	1606	989	2162
Dallas	1510	50	66	---	116	454	50	407	483	---	---	---	---	251	227	288
Daviess	4085	7	588	---	595	922	150	687	1028	593	110	---	---	863	474	677
DeKalb	3610	2	---	185	187	759	181	698	649	554	381	202	---	880	416	506
Dent	1675	18	24	---	42	576	53	505	499	---	---	---	---	265	262	351
Douglas	403	---	---	---	---	73	15	185	---	130	---	---	---	92	91	45
Dunklin	9933	---	1134	703	1837	1878	439	786	1302	2439	696	---	557	2199	755	1572
Franklin	7694	552	16	148	716	2004	396	2274	30	2127	---	121	27	1595	1356	1286
Gasconade	3477	177	16	---	193	793	68	912	371	1018	---	120	---	881	477	503
Gentry	5406	27	---	---	27	964	186	1621	542	309	1445	223	90	1192	866	586
Greene	6274	479	104	91	674	1813	215	1342	2108	22	74	---	26	1087	806	1123
Grundy	5430	5	---	**	1	2145	447	934	1151	342	33	255	122	934	634	1293
Harrison	3206	5	190	29	224	1266	65	686	---	590	133	239	4	635	403	811
Henry	6310	52	479	29	560	1839	134	1525	1660	542	---	---	50	1142	867	1230
Hickory	1923	7	---	---	7	646	---	588	682	---	---	---	---	339	270	388
Holt	8476	---	---	502	502	1309	---	1633	727	489	3070	570	176	2054	874	850
Howard	4651	19	---	25	44	1438	366	1185	450	368	348	451	1	1011	716	865
Howell	4224	50	80	---	130	973	127	1140	1854	---	---	---	---	851	599	602
Iron	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Jackson	5423	1968	92	472	2532	149	23	555	2	384	949	364	465	1274	506	335
Jasper	9917	95	183	2508	2786	2826	26	1820	15	1911	276	187	70	1725	1191	2095
Jefferson	645	341	---	---	341	140	---	81	78	4	---	---	1	94	71	121
Johnson	3699	100	---	114	214	815	275	390	683	587	379	259	97	917	351	526
Knox	4063	24	395	---	419	2205	314	351	284	60	76	356	**	559	372	1425
Laclede	5499	11	96	---	107	1856	87	1277	2172	---	---	---	---	986	639	1121
Lafayette	18581	101	26	17	144	4489	474	4432	102	2785	5115	1005	35	4400	2401	2731
Lawrence	8227	16	---	---	16	2783	128	1603	3696	---	---	---	1	1546	798	1675
Lewis	9995	26	---	41	67	3456	1101	2472	427	1873	2	597	---	1944	1645	2092
Lincoln	10312	327	10	202	539	3708	579	2310	---	2404	662	81	29	1827	1481	1984

** Credits exceeded shipments

APPROXIMATE TONNAGE BY COUNTIES OF FERTILIZERS SHIPPED FOR USE IN MISSOURI, JANUARY 1 THRU JUNE 30, 1989.

COUNTIES	TOTAL ALL FERTILIZERS	MIXED FERTILIZER				FERTILIZER MATERIALS								PLANT FOOD		
		BAGGED	BULK DRY	LIQUID	TOTAL MIXED FERTILIZER	POTASSIC MATERIALS	PHOSPHATIC MATERIALS	AMMONIUM PHOSPHATES	AMMONIUM NITRATE	UREA	NITROGEN SOLUTIONS	ANHYDROUS AMMONIA	MISC. MATERIALS	NITROGEN	AVAILABLE P_2O_5	SOLUBLE K_2O
Adair	3959	209	321	270	800	1015	144	196	18	922	606	201	57	890	286	770
Andrew	4808	60	100	30	190	730	159	804	425	797	91	1589	21	2001	482	477
Atchison	11530	25	661	778	1464	991	103	783	71	1127	3449	3348	194	4646	736	834
Audrain	16143	171	---	758	929	5644	1380	1382	1	2708	1254	2601	244	4053	1527	3481
Barry	9778	134	500	---	634	2472	216	1476	4969	26	---	---	5	2031	863	1564
Barton	12810	91	795	97	983	2108	302	1366	634	2030	3926	928	533	3455	1014	1396
Bates	21342	590	180	995	1765	4124	412	3923	2616	5669	1241	1254	338	5769	2278	2720
Benton	4486	213	---	---	213	818	103	1230	---	1571	27	203	321	1205	650	522
Bollinger	2002	98	---	113	211	481	---	601	---	696	13	---	---	451	309	321
Boone	9232	438	21	1388	1847	2091	357	644	19	1524	2061	609	80	2123	827	1415
Buchanan	7210	295	418	1740	2453	619	75	582	244	1285	1376	523	53	1789	641	760
Butler	17630	144	2	---	146	5684	1442	2047	487	6693	840	252	39	4107	1616	3422
Caldwell	5385	59	---	436	495	917	231	905	789	1160	524	334	30	1420	601	637
Callaway	7298	227	---	55	282	1809	177	1058	177	2261	1157	327	50	1935	628	1142
Camden	77	66	---	---	66	---	---	---	---	---	---	---	11	5	3	4
Cape Girardeau	14369	1181	698	1019	2898	2626	1032	986	1436	2233	1149	1647	362	3760	1305	2059
Carroll	13680	186	---	1205	1391	2235	353	477	327	2020	3911	2405	561	4579	611	1440
Carter	7	7	---	---	7	---	---	---	---	---	---	---	---	---	1	1
Cass	10974	396	830	511	1737	1807	163	1245	1154	1808	1566	1118	376	3013	967	1384
Cedar	2645	202	---	---	202	754	139	497	549	478	26	---	---	526	321	477
Chariton	17502	150	2	4285	4437	2237	275	1534	---	2704	2987	2147	1181	4841	1282	2001
Christian	4111	93	77	---	170	1466	181	832	921	487	---	---	54	706	487	885
Clark	8045	264	290	1431	1985	3383	305	1231	59	613	**	1818	60	1661	1119	2391
Clay	918	404	20	3	427	5	1	273	15	20	2	41	134	190	148	26
Clinton	6241	105	---	155	260	781	243	1044	1653	1449	428	302	81	1798	619	515
Cole	6846	724	---	---	724	1459	98	1191	833	1804	258	223	56	1689	675	953
Cooper	12582	299	227	47	573	2264	436	1609	1612	2989	826	2267	6	4342	1058	1474
Crawford	228	41	187	---	228	---	---	---	---	---	---	---	---	44	31	31
Dade	15770	108	144	---	252	5055	499	1730	6348	819	252	61	754	3114	1057	2926
Dallas	3603	47	197	---	244	760	215	730	1431	173	---	18	32	742	466	486
Daviess	4745	118	24	89	231	768	240	966	686	612	900	339	3	1236	594	500
DeKalb	6480	1	50	1559	1610	699	254	796	433	902	982	743	61	1677	729	689
Dent	4174	152	---	---	152	1179	223	978	1567	23	---	---	52	746	571	726
Douglas	1177	70	4	---	74	402	27	303	---	350	---	21	---	240	159	259
Dunklin	39679	53	5182	77	5312	7296	2522	1620	4562	4389	10269	210	3499	8655	2416	5811
Franklin	11650	1395	88	545	2028	2485	258	1239	563	3848	321	904	4	3252	1083	1719
Gasconade	6577	495	6	1	502	1800	82	1372	277	2408	25	81	30	1579	746	1157
Gentry	8836	77	---	---	77	1745	268	1440	1910	916	1512	952	16	2482	848	1073
Greene	14105	1554	125	219	1898	3923	584	2321	5228	44	23	---	84	2456	1508	2414
Grundy	10730	92	---	7	99	2603	696	1703	2312	1186	978	1002	151	2734	1182	1587
Harrison	9210	263	1127	443	1833	1154	333	947	167	1828	1513	1365	70	2765	943	1081
Henry	9921	191	692	21	904	1144	407	2202	3275	1404	193	300	92	2570	1351	833
Hickory	977	27	---	---	27	165	174	50	458	51	---	---	52	202	103	95
Holt	10011	5	24	2166	2195	519	16	357	4	254	3926	2545	195	3594	509	494
Howard	6870	30	49	172	251	1254	230	703	1048	990	1215	1167	12	2282	454	786
Howell	12430	282	51	---	333	4115	729	3718	3535	---	---	---	---	1896	2075	2513
Iron	98	96	---	---	96	---	1	---	---	1	---	---	---	14	12	12
Jackson	9900	4512	381	1143	6036	286	8	1497	---	144	957	718	254	2057	1265	620
Jasper	11516	436	140	3513	4089	2212	101	1526	---	1753	954	290	591	2117	1193	1823
Jefferson	1525	554	---	19	573	239	97	228	327	48	---	---	13	234	204	196
Johnson	11007	220	---	1536	1756	1882	267	1846	857	1900	1392	1028	79	2818	1281	1431
Knox	6338	73	1337	31	1441	1053	444	660	1751	132	182	637	38	1561	714	966
Laclede	5033	223	180	---	403	1170	239	935	1792	469	---	---	25	1040	593	733
Lafayette	16993	125	40	**	135	2977	297	2896	28	5150	528	4301	681	6620	1546	1833
Lawrence	8809	59	---	1	60	2490	448	1657	3828	302	---	---	24	1744	975	1465
Lewis	12213	154	573	124	851	3477	1139	832	1112	2348	81	2030	343	3403	1075	2307
Lincoln	11201	314	22	46	382	2551	719	1462	15	3257	1245	1561	9	3454	1090	1616

** Credits exceeded shipments.

APPROXIMATE TONNAGE BY COUNTIES OF FERTILIZERS SHIPPED FOR USE IN MISSOURI, JULY 1 THRU DECEMBER 31, 1988.

COUNTIES	TOTAL ALL FERTILIZERS	MIXED FERTILIZER				FERTILIZER MATERIALS								PLANT FOOD		
		BAGGED	BULK DRY	LIQUID	TOTAL MIXED FERTILIZER	POTASSIC MATERIALS	PHOSPHATIC MATERIALS	AMMONIUM PHOSPHATES	AMMONIUM NITRATE	UREA	NITROGEN SOLUTIONS	ANHYDROUS AMMONIA	MISC. MATERIALS	NITROGEN	AVAILABLE P_2O_5	SOLUBLE K_2O
Linn	7325	4	26	---	30	1909	619	2159	507	1789	152	160	---	1560	1284	1154
Livingston	6800	16	---	---	16	2866	680	1588	483	1045	37	58	27	996	1042	1728
McDonald	28	16	12	---	28	---	---	---	---	---	---	---	---	3	3	3
Macon	8467	36	964	219	1219	2126	682	2209	---	1776	184	220	51	1563	1547	1604
Madison	1082	33	70	---	103	329	23	398	---	229	---	---	---	193	211	215
Maries	22	---	---	22	22	---	---	---	---	---	---	---	---	---	2	2
Marion	11794	32	249	2	283	5679	631	2255	684	926	574	738	24	1843	1389	2929
Mercer	1061	---	---	---	---	106	50	155	255	403	52	40	---	347	94	63
Miller	355	25	---	---	25	104	25	103	73	25	---	---	---	57	62	65
Mississippi	13638	---	---	239	239	2831	436	562	696	2469	6052	59	294	3492	540	1698
Moniteau	4646	96	---	176	272	1800	246	1200	26	885	156	61	---	739	723	1125
Monroe	7253	25	51	674	750	2332	98	2230	851	587	284	60	61	1149	1193	1558
Montgomery	11814	66	---	142	208	3492	533	4192	428	2740	**	257	10	2362	2186	2161
Morgan	3229	146	---	---	146	947	64	1039	225	808	---	---	---	652	529	590
New Madrid	12873	1	1263	522	1786	3512	243	1013	384	3103	2484	79	269	2803	870	2533
Newton	2407	51	195	3	249	673	5	327	1125	---	25	---	3	490	178	444
Nodaway	11361	108	90	34	232	2706	293	2171	1154	861	3439	442	63	2600	1203	1669
Oregon	2214	---	85	---	85	521	80	691	837	---	---	---	---	420	365	323
Osage	3201	137	14	---	151	1008	75	901	719	307	---	40	---	598	471	634
Ozark	622	1	128	---	129	206	51	107	129	---	---	---	---	79	89	140
Pemiscot	13367	---	1324	3085	4409	1098	130	54	92	1111	6171	6	296	3091	421	1325
Perry	5733	96	197	---	293	1676	315	1244	643	956	80	502	24	1338	782	1061
Pettis	7772	197	---	108	305	2868	---	1948	856	942	293	252	308	1414	948	1811
Phelps	1853	97	22	---	119	562	25	454	655	38	---	---	---	336	239	349
Pike	10069	59	1082	41	1182	4643	122	1953	5	1236	496	414	18	1675	1198	1658
Platte	5243	39	94	41	176	684	6	932	2176	343	566	340	22	1516	476	424
Polk	4689	18	---	---	18	1222	161	1153	1851	214	---	---	70	946	607	725
Pulaski	1810	17	---	---	17	399	---	593	801	---	---	---	---	381	274	240
Putnam	3694	73	53	25	151	660	77	889	78	747	942	---	150	847	470	423
Ralls	5060	30	17	1054	1101	1295	101	1261	24	726	450	74	28	792	787	1048
Randolph	5010	85	---	1074	1159	1219	127	1020	697	558	190	---	40	797	681	916
Ray	5494	24	---	---	24	1519	421	1428	298	1114	464	226	---	1163	876	920
Reynolds	11	11	---	---	11	---	---	---	---	---	---	---	---	1	1	1
Ripley	740	---	3	---	3	224	63	160	49	241	---	---	---	156	102	135
St. Charles	10856	1125	440	759	2324	2181	821	1011	484	998	2141	802	94	2423	1314	1531
St. Clair	3962	47	---	---	47	736	109	1181	1371	341	177	---	---	893	602	451
St. Francois	2650	92	1	6	99	648	76	768	132	761	---	---	166	581	400	402
Ste. Genevieve	3583	193	---	---	193	1102	179	686	17	1072	173	159	2	820	434	698
St. Louis	5749	4598	152	---	4750	38	94	7	31	418	1	3	407	1050	418	459
Saline	13961	26	---	182	208	4678	766	2479	---	2472	1295	1837	226	3460	1554	2853
Schuyler	1778	---	59	24	83	571	107	399	---	413	126	79	---	372	248	351
Scotland	4541	2	48	181	231	1203	273	1106	448	669	542	69	---	893	689	736
Scott	4962	20	379	26	425	1837	152	504	707	756	345	172	64	951	357	1227
Shannon	1481	---	---	---	---	423	25	512	---	521	---	---	---	331	246	253
Shelby	10131	---	462	---	462	3623	938	2589	361	1692	4	258	204	1671	1703	2300
Stoddard	23299	32	---	46	78	4597	1419	4417	86	9530	1906	448	818	6274	2695	2766
Stone	720	17	---	---	17	158	14	---	528	---	---	---	3	182	7	100
Sullivan	1978	---	23	---	23	356	209	615	50	520	205	---	---	429	381	216
Taney	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Texas	4716	55	---	---	55	1390	47	1361	1770	---	---	---	93	873	656	861
Vernon	11218	---	---	76	76	3559	97	3728	---	3101	487	135	35	2342	1780	2163
Warren	2593	70	---	24	94	656	95	772	---	778	---	182	16	656	413	407
Washington	330	39	---	---	39	50	70	---	73	---	---	---	98	40	36	34
Wayne	695	1	---	---	1	199	53	214	77	151	---	---	---	134	122	119
Webster	4609	35	10	---	45	1426	54	1061	2023	---	---	---	---	886	519	863
Worth	1407	---	2	---	2	289	---	179	506	100	175	142	14	419	82	174
Wright	5622	12	---	6	18	1725	158	1601	2097	---	---	---	23	1003	811	1041

** Credits exceeded shipments.

APPROXIMATE TONNAGE BY COUNTIES OF FERTILIZERS SHIPPED FOR USE IN MISSOURI, JANUARY 1 THRU JUNE 30, 1989.

COUNTIES	TOTAL ALL FERTILIZERS	MIXED FERTILIZER				FERTILIZER MATERIALS								PLANT FOOD		
		BAGGED	BULK DRY	LIQUID	TOTAL MIXED FERTILIZER	POTASSIC MATERIALS	PHOSPHATIC MATERIALS	AMMONIUM PHOSPHATES	AMMONIUM NITRATE	UREA	NITROGEN SOLUTIONS	ANHYDROUS AMMONIA	MISC. MATERIALS	NITROGEN	AVAILABLE P_2O_5	SOLUBLE K_2O
Linn	7982	107	418	1	526	2704	358	1332	453	1954	234	419	2	1770	853	1727
Livingston	7378	107	46	17	170	1891	372	1103	1304	1613	685	158	82	1736	703	1172
McDonald	24	22	...	2	24	...	...	...	...	...	...	...	...	3	3	3
Macon	11929	107	1339	826	2272	3233	461	1201	303	2079	1547	704	129	2535	1148	2402
Madison	1444	136	...	2	138	395	59	443	...	409	...	...	...	282	246	252
Maries	279	8	...	72	80	...	...	...	...	24	175	...	...	71	7	7
Marion	9963	109	30	35	174	1677	531	819	1418	1046	1899	2078	321	3439	684	1033
Mercer	1843	...	...	23	23	591	126	262	509	...	52	277	3	461	182	359
Miller	4497	178	63	...	241	1173	...	984	422	1616	...	61	...	1134	495	747
Mississippi	26409	5	11	300	316	4066	827	582	2750	3244	11537	1837	1272	7886	745	2276
Moniteau	9497	252	...	595	847	1353	124	1749	53	2907	2099	385	...	2642	1025	978
Monroe	13478	59	107	2034	2200	2535	712	1618	1530	2639	1698	302	244	2962	1418	1985
Montgomery	16290	219	10	1490	1719	3209	688	1647	550	4985	1577	1684	231	4813	1374	2240
Morgan	4004	236	...	...	236	1152	74	796	244	1444	51	...	7	930	439	735
New Madrid	40681	4	4503	1237	5744	6091	544	1151	1929	9002	13266	1849	1405	11710	1344	4832
Newton	3494	89	819	15	923	520	83	385	1520	54	...	...	9	783	298	650
Nodaway	21210	149	215	2315	2679	2684	429	2178	1197	3122	6654	1888	379	5929	1728	1975
Oregon	5994	46	129	...	175	1524	297	1513	2485	...	...	...	...	1137	857	936
Osage	10372	406	27	...	433	2206	105	1735	3080	2211	357	243	2	2722	912	1403
Ozark	4832	49	255	...	304	1525	91	1031	1728	149	...	...	4	881	555	954
Pemiscot	30022	32	664	2696	3392	2461	833	306	454	5334	16482	97	663	8424	887	1850
Perry	10174	373	61	137	571	1589	441	746	2268	1645	781	2061	72	3633	644	1009
Pettis	14242	296	73	1055	1424	2317	287	2334	2800	2408	676	1315	681	3908	1386	1663
Phelps	3570	378	22	...	400	961	72	865	719	517	5	20	11	706	477	623
Pike	15698	385	1515	517	2417	7039	185	1013	829	1392	1507	1035	281	2687	1003	1733
Platte	5718	55	206	364	625	541	145	941	743	390	1485	788	80	1732	581	381
Polk	10931	163	14	...	177	3900	418	2453	3092	734	...	19	138	1884	1344	2344
Pulaski	5017	200	46	...	246	945	161	1512	1789	127	158	...	79	1025	797	594
Putnam	6288	253	913	110	1276	1346	90	740	957	779	1052	20	28	1338	572	1020
Ralls	6187	83	81	1780	1944	1357	319	759	83	734	736	166	69	976	789	1180
Randolph	9303	788	...	2377	3165	1090	119	518	1133	881	1959	167	291	1837	675	1223
Ray	10538	104	...	...	104	1146	199	1064	623	1852	3857	1645	48	3670	618	708
Reynolds	173	165	...	...	165	1	...	...	...	7	...	...	...	23	21	22
Ripley	3417	11	35	...	46	1139	273	707	348	904	...	...	...	666	456	688
St. Charles	12289	1729	387	525	2641	1361	329	380	881	1443	3168	1968	118	4060	666	1014
St. Clair	4237	34	...	7	41	689	178	1313	596	1165	205	...	50	1045	691	419
St. Francois	3518	445	8	...	453	835	169	875	206	811	24	...	145	689	537	559
Ste. Genevieve	7744	499	49	103	651	1161	331	1008	200	2850	524	821	118	2512	748	793
St. Louis	9680	8333	136	...	8469	85	78	24	49	214	60	6	695	1623	522	631
Saline	20233	39	...	872	911	3413	334	3408	...	4568	4108	2850	641	6329	1981	2184
Schuyler	1705	9	187	157	353	482	...	159	...	131	430	120	30	343	162	340
Scotland	5415	37	227	538	802	1648	305	152	430	490	1182	391	15	1139	407	1065
Scott	17530	228	951	1459	2638	3204	763	376	1470	1642	4949	2101	387	4994	795	2256
Shannon	505	20	...	...	20	179	101	103	102	...	...	...	...	55	96	110
Shelby	14930	61	1286	142	1489	3928	1084	1739	1518	2862	1153	845	312	3412	1532	2598
Stoddard	45359	89	115	988	1192	11124	1682	5323	1012	14333	3775	3725	3193	12737	3430	6822
Stone	3650	26	...	...	26	1228	51	723	1622	...	...	...	...	684	359	762
Sullivan	4255	36	610	387	1033	948	25	657	448	506	336	287	15	995	426	746
Taney	109	36	68	...	104	...	...	...	...	2	...	...	3	12	11	11
Texas	9601	386	...	...	386	2472	409	2415	3842	49	...	20	8	1824	1352	1536
Vernon	13639	68	12	172	252	3033	308	2649	455	4950	1186	767	39	3877	1434	1825
Warren	4146	148	...	129	277	974	175	542	4	1485	306	346	37	1180	382	607
Washington	807	102	2	...	104	167	212	...	303	21	...	...	...	123	112	113
Wayne	1606	12	3	...	20	497	125	368	273	268	...	...	55	295	229	300
Webster	13426	254	12	11	277	4606	374	3143	4734	285	2	...	5	2342	1652	2779
Worth	2658	...	...	...	...	237	97	671	410	462	378	403	...	909	353	162
Wright	18814	200	...	12	212	5591	355	5016	7374	253	...	...	13	3537	2497	3407

** Credits exceeded shipments.

Conventional
and
Low-Input
Agriculture

Economic and Environmental Evaluation, Comparisons and Considerations

A White Paper Report
August, 1989

Potash & Phosphate Institute (PPI)
Suite 401
2801 Buford Hwy, N.E.
Atlanta, GA 30329

Conventional and Low-Input Agriculture

Economic and Environmental Evaluation, Comparisons and Considerations

Explanation of Terms:

In this report, reference to "conventional agriculture" is not meant to include any and all currently used farming methods. Rather, the phrase implies modern, site specific, progressive, science-based production systems where available and applicable technologies and inputs are used effectively and efficiently. Conventional agriculture in this context shows concern for the environment as well as profitability.

Highlights of Topics Discussed in This Report

- **A primary** driving force behind the Low-Input Sustainable Agriculture (LISA) movement is a heightened concern for groundwater quality and agriculture's perceived role. LISA advocates claim ...often unsupported by scientific data... that cutting back on purchased inputs will reduce farmer risks, minimize groundwater pollution, revitalize farm communities and eliminate crop surpluses.
- World population is expected to reach about 6.0 billion by the year 2,000. Harvested crop acres per person will drop to 0.32, down from 0.43 in 1980.
- Contrary to common perception, commercial fertilizer use in the U.S. is not increasing rapidly. Since the late 1970s, per acre N rates have gone up only slightly, while P and K rates have actually declined. Soil test summaries for P and K continue to show the need for stronger fertilization programs across North America.
- Supplying adequate, balanced plant nutrition including the use of commercial fertilizers with other best management practices (BMPs) will insure efficient nutrient use, minimize environmental impacts of crop production and help maintain profitable crop production levels.
- Growing legumes in rotation with grain crops such as corn to efficiently provide N for both crops will require relatively high levels of all nutrients other than N. Legume yields, as well as their quality and ability to fix N, will be determined by the availability of P, K and other nutrients that must be replenished from external sources.
- It is estimated that there are less than 2.0 million tons of N available from animal manures in the U.S., representing only 18 percent of the total N use. Available manure in the twelve Corn Belt states can provide only about 11 percent of the need for N in that region.
- Substituting animal manures and/or legumes for commercial N fertilizer does not guarantee a groundwater supply safe from nitrates. Indeed, research has shown that all N sources including legumes, manure, soil orgainc matter and commercial fertilizers produce nitrate through biological processes. Further, research has shown that controlling nitrate-N leaching is actually more practical with commercial N sources because BMPs can be used to regulate the application and release N supplies to crops and increase crop nutrient use efficiency.
- Increasing livestock numbers to provide manure to replace commercial N would be a gigantic and costly task, virtually impossible to accomplish. Supply/demand balance for beef, for instance, would break down quickly destroying profitability in the livestock industry.
- Rotating corn with a legume would cost growers billions in lost grain sales. At the same time, excess hay production would drive prices down and make hay production unprofitable.
- Whether applied as organic materials, commercial fertilizers or derived from soil organic matter, nutrients undergo the same biological and chemical transformations in the soil that result in identical ionic forms being available to and utilized by plants.
- Any produce exported from a farm, whether as animal products (meat, milk, eggs), grain, forage or fiber, contains large amounts of nutrients taken from the soil. Simply moving nutrients from one site to another on the farm through the use of on-farm wastes or crop residues does nothing to replace the nutrient needs of the system. Maintaining productivity requires that nutrients be provided from some external source.
- Replenishment of nutrients lost in produce removed from the farm can occur through purchased feeds, use of off-farm waste sources, from legumes (N) and from commercial fertilizers. Commercial fertilizers provide the most efficient, balanced and economic means of restoring soil fertility while being most environmentally safe and manageable.

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❧ Introduction

Recent economic and environmental issues have raised questions as to the validity of continually improving "conventional" farming practices. Some suggest a "revolutionary" approach under the banner of low-input sustainable agriculture (LISA) rather than current production systems.

Government policymakers, the U.S. Department of Agriculture (USDA), university administrators, and various agricultural interests are debating the issue. Environmental organizations, organic farming advocates and numerous political activists with interest in agricultural legislation support low-input farming. Decisions made will determine if increased research and extension support will be given to develop low-input systems and if government policies will provide incentives for farmers to use low-input methods.

A primary force behind the low-input movement is agriculture's role in non-point source pollution of groundwater. Among the claims are that modern, intensive farming methods cause increased erosion, that current production cannot be sustained, and that petroleum-based inputs must be conserved. Low-input farming interests claim that cutting back on purchased inputs would reduce farmer risks, minimize the role agriculture plays in non-point source groundwater pollution, revitalize farm economies and eliminate crop surpluses.

Conventional production agriculture is a system which has developed through a long history of agronomic and soil conservation research. This research has evaluated those numerous controllable factors necessary to grow each crop profitably. When these factors are integrated and implemented into a cropping system they represent **best management practices** (BMPs) for that system. BMPs vary from state to state, crop to crop, farm to farm and soil to soil. If low-input systems are to become a factor in U.S. agriculture, they should also be based on a sound, scientific approach. Before conventional farmers are given incentives to switch to low-input systems, the decision makers should be content with answers to the following questions:

- Should U.S. agriculture maintain its position as a reliable food source? What is the social and economic impact of food shortages?
- How important is it to this country to help meet world food needs and have U.S. agricultural products available for world trade?
- Will low-input systems assure stability in both the crop and livestock sectors of the agricultural economy?
- Will funding for low-input research and extension efforts be in addition to, or in place of, current agricultural program funds? Are dollars spent for research, education, and low-input incentive programs jeopardizing the education needed to implement BMP programs for conventional farming and the research needed to further develop these practices?
- Will low-input systems improve any detrimental effects agriculture may have on groundwater and the environment? Will increasing the availability of legumes and animal manures to replace fertilizer nitrogen (N) reduce the levels of nitrates in groundwater?

The Need for U.S. Farmers to Produce Has Not Changed

U.S. farmers are the world's most dependable food suppliers. Their productive capacity has enabled the American family to spend an average of less than 15 percent of its disposable income for food, lower than any other nation. U.S. farmers have been the dominant supplier of food aid when and where it is needed throughout the world, a world which demands more food as population increases over 230 thousand daily, 85 million annually and is expected to reach 6 billion by the year 2,000.

> *"We can not go back to the past in agriculture, any more than we can go back to the past in medicine, space, transportation or any other branch of science and culture."* --Tommy Irvin, Commissioner, Georgia Department of Agriculture.

The increased food demand will have to be obtained from a relatively stable acreage base, or from limited additions of new, less productive, and more erosive soils. There is little good, new land. The numbers in **Table 1** show the effect population increases are having on the land base used for food production. World farmers harvested 0.43 acres of major crops per person in 1980. That figure decreased to 0.37 acres in 1988 and is predicted to drop to 0.32 acres by the year 2000 (Bureau of Mines, 1988). Until population growth slows, food production must increase more than 2 percent annually just to maintain world diets and current standards of living (Walsh, 1985). Higher annual increases in food production would be needed if diets and standards of living are to be improved.

Table 1. World population and major crop acres harvested trends.

Year	World Population	World Harvested Crop Acres	Harvested Acres Per Person
	---- millions ----		
1980	4.450	1.916	0.43
1988	5.082	1.873	0.37
2000	6.000	1.931	0.32

The delicate world food supply balance came into sharp focus in 1988 when drought occurred in major food producing regions.

A Policy to Replace Conventional with Low-Input Farming

Congress has appropriated money to the USDA to look for alternative farming systems. These funds have enabled the establishment of the LISA program within USDA. Organic farming advocates are having a strong influence on how these monies are spent. Environmentalists who have always expressed opposition to the use of purchased inputs in food production have rallied under the LISA banner. Congress is under great pressure to strengthen groundwater legislation. Agricultural inputs, especially N, phosphorus (P), and pesticides, are cited as non-point source pollutants.

> "*A viable agriculture requires a strong effort in science and technology.*" --Report of a Task Force of the Council for Agricultural Science and Technology (CAST), 1988.

Low-input farming has developed into a movement for those who believe that conventional agriculture has severe environmental and economic limitations and that low-input systems will solve these problems. There is little scientific basis at present to support the contention that low-input systems will work better in **mainstream agriculture** than the BMPs of conventional agriculture.

> "*I am concerned that the sustainability movement is pressing for adoption of agricultural practices under the banner of sustainability before either the science has been done or the technology is available.*"--Dr. V. W. Ruttan, Agricultural Economist, University of Minnesota, 1988.

❧ Conventional Versus Low-Input Cropping Systems

There are many production input practices that are common to both conventional and low-input cropping systems, but there are also several key differences. Some of the common practices are cited by the low-input advocates as being part of the justification to support their view that agricultural practices must change. For example, rotations would be a BMP for both systems, but are often cited as an advantage for the low-input system. A survey (USDA-ERS, 1988) showed that over 70 percent of the corn crop in 10 Corn Belt states is grown in rotation. Rotations are a BMP for the majority of current Corn Belt farmers because yields are increased 5 to 15 percent and pest problems are reduced. Rotations exist despite the claim by low-input advocates that current government commodity programs discourage their use. Other examples of common BMPs are soil and water conservation practices, best hybrids and varieties, and integrated pest management. Some of the major differences as promoted by LISA advocates are:

1. Increased use of forage legumes in rotation with cash crops rather than cash crop (grain, oil, and fiber) rotations.
2. Increased diversification of cash crop farms to livestock/crop farms.
3. Increased use of forage legumes, animal manures and sewage sludge to replace purchased fertilizer.
4. Use of cultivation, time of planting, and labor as substitutes for purchased pesticides.

A statement from the USDA on the low-input movement gives an indication of the intent for the program: *"A major focus of USDA's effort to develop cost-effective conservation systems is the spectrum of systems referred to as alternative agriculture or sustainable agriculture. Alternative agriculture connotes farming systems that economize on the use of manufactured inputs, notably fertilizers and pesticides, but also chemicals used to prevent livestock diseases or promote growth. The emphasis is on minimizing the use of agricultural chemicals without drastically reducing crop yields or livestock production."* --(USDA, 1989).

Low-input agriculture would have an emphasis on replacing commercial fertilizer with legumes in rotation, cover crops, animal manures, and other organic waste products. Grain crops would be grown in rotation with legumes, resulting in a reduction in grain crop acreage or more land brought into production to maintain grain acres, diversification of grain farms into livestock/grain farms, increased animal numbers, expanded farm labor requirements, and different, often more intensive, farm management skill requirements.

❧ Fertilizer Use in Conventional and Low-Input Systems

Although some contend that fertilizers are destroying good soils, substantial evidence to the contrary exists. Long-term studies at experiment stations across the U. S. are producing yields equal to, or better than, any in the past. The humus and organic-N content of soils in New Zealand and Australia increased when adequately treated with P and sulphur (S). The Broadbalk plots of the Rothamsted Experiment Station in England, which have received commercial fertilizer since 1843, are more productive today than at any time in the recorded past. At the Askov station in Denmark, comparisons over 50 years showed that commercial fertilizers were more effective than organic sources. The aggregating action from enhanced root proliferation and greater amounts of decaying residues from well fertilized crops have enhanced soils and made them more friable, tillable and receptive to water (Olson, 1972).

> *"We can't honor unresearched views that we can get along without chemicals and fertilizers."* --Dr. Woody Miley, Extension Agronomist, University of Arkansas.

Fertilizer Use and Soil Test Levels

One of the major justifications offered for moving to low-input systems is the claim of excessive and inefficient use of commercial fertilizer in conventional crop production. Some believe that government programs and encouragement from agribusiness cause farmers to seek **maximum** production rather than **profitable** production and have made over-fertilization a common practice.

USDA statistics for the past 10 years don't support this contention. **Table 2** shows total fertilizer used per harvested crop acre in the U.S. Nitrogen use has increased only slightly since 1979, while P and potassium (K) use has declined. This has been in response to a less favorable farm economic climate during the decade. There is considerable disagreement whether this "stagnation" is good, bad or appropriate.

Table 2. Fertilizer use per harvested crop acre.[1]

Year	N	P_2O_5*	K_2O*
	-	-------lb/A------	
1978	70	36	39
1982	70	31	36
1987	74	29	35

[1] Figures not adjusted for non-agricultural use, so actual lb/A use on crops is lower

* P_2O_5 and K_2O are expressions used in fertilizer analysis for P and K.

> *"World population pressures, to say nothing of the potential markets for biomass in the future to fuel chemical feedstock needs, will not allow us to return to the on-farm recycling and resource dependence of the first 99 centuries of agricultural history. It would appear that, at least for the foreseeable future, we will need a viable fertilizer industry. It may well become an industry that will supply nutrients as the final component in a total nutrient management system after all other nutrient sources in the total nutrient pool have been tapped. But this concept is no different than the one espoused by most agronomists and land grant experiment stations for years."* --Dr. Fred Miller, Ohio State University, and Dr. Bill Larson, University of Minnesota,1988.

Conventional farmers who are in the business to stay are economically efficient. They use soil tests and other sound agronomic practices geared to realistic, challenging yield goals which improve the efficiency of all purchased inputs. Soil test summaries from North America, shown in **Figures 1 and 2,** indicate that in many states and provinces, more than 50 percent of soils test medium or less in P and K. Also, many soils continue to need adequate liming so that all applied and indigenous nutrients can be used most efficiently (PPI, 1987). Incentive programs geared to reducing purchased inputs, if adopted by farmers with soil test levels already below optimum, would place serious limitations on the ability of those soils to produce at profitable yield levels.

Superior land stewardship and crop management are not achieved in a single year. It is a cumulative process and must be practiced each year to achieve and maintain a productive and profitable cropping system. A long-term experiment in Tennessee (PPI, 1983) shows what can happen when farmers allow soil test levels to become depleted (**Table 3**). Where K was left out of the fertilizer program for several years (low-K soil test), adding extra increments of K, in a single year, did not return this soil to the productive potential of the soil maintained at the higher nutrient level.

Table 3. Effects of residual K and rates of added K on corn grain yields.

K_2O Applied	Low-K Soil Test	Med-K Soil Test
lb/A	------- Yield,bu/A -------	
0	59	136
30	95	158
60	128	153
90	119	162

Hartsells loam soil, Tennessee

Figure 1. Phosphorus Soil Test Summary - Percent testing medium or less.

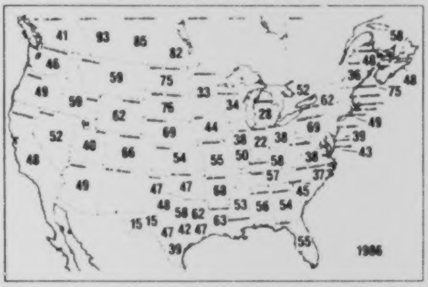
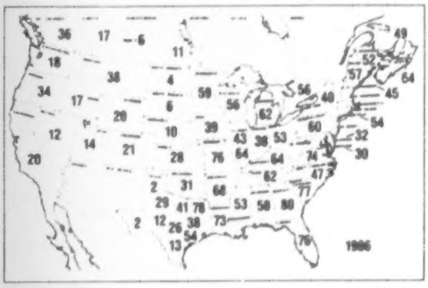


Figure 2. Potassium Soil Test Summary - Percent testing medium or less.



"If sediment loss is stopped, there is essentially no problem with P and K losses on most soils. Erosion is a culprit, not applied P and K." --Dr. Jerry Mannering, Purdue University.

" Adequate levels of soil P and/or K are needed to optimize the use of available N supplies by both dryland and irrigated crops. Therefore, maintaining adequate levels of available P and K will improve N use-efficiency by the growing crop and reduce the potential of NO_3*-N loss by leaching, assuming good irrigation and N fertilization management practices are used."* --Dr. Ardell D. Halvorson, USDA, ARS, Akron, Colorado.

Fertilization, Soil Erosion and Input Efficiency

When soil erosion is minimized, so are the losses of P to the environment. Whether in conventional or low-input systems, soil and water conservation measures are BMPs.

Using adequate P with other BMPs will help assure its efficient utilization, minimize environmental problems, and help maintain profitable crop production levels. Farmers must recognize that both agronomic and conservation BMPs are site specific and must be integrated together...and specifically for each field and each crop produced.

Research with corn in Illinois (Wagner, 1980) demonstrates the importance of balancing nutrients for higher yields and nutrient efficiency. See **Table 4**.

Numerous agronomic factors interact with a soil fertility program. Rotation, planting date, population, variety or hybrid selection and other factors determine the efficiency of a fertilizer program as much, or more than, the rate, timing and placement of fertilizer. Only when the whole range of production practices is put together into a maximum economic yield (MEY) system will the highest possible fertilizer efficiency be obtained (PPI, 1988c, **Table 5**).

Table 4. Illinois corn research demonstrates the importance of balanced nutrition for yield and fertilizer efficiency.

Fertilizer Rate N	Fertilizer Rate P_2O_5	Fertilizer Rate K_2O	Grain Yield	Nutrient Efficiency N	Nutrient Efficiency P_2O_5	Nutrient Efficiency K_2O
	lb/A		bu/A		------bu/lb------	
0	60	90	41			
180	60	0	96	.53	1.60	----
180	0	90	111	.62	----	1.23
180	60	90	143	.79	2.38	1.59

A report of the United Nations' Food and Agriculture Organization (FAO) summarized the importance of using fertilizer in balance with other production inputs. The report stated, "Fertilizer efficiency can be reduced by as much as 10 to 50 percent by improper management of other cultural practices. Only the whole gamut of established agronomic skills will insure the highest effectiveness of fertilizer."

Table 5. The effects of several production inputs on corn yield and fertilizer efficiency from various locations.

Production Factor	Yield	Efficiency P_2O_5	Efficiency N	N Balance Sheet[1] soil supplied(-) unused fert. N(+)	State
	bu/A	--- bu/lb ---		lb/A	
Rotation:					
continuous	105	2.10	.88	+ 14	
rotation	120	2.40	.96	- 6	NC
Irrigation:					
without	127	1.02	.51	+ 85	
with	214	1.71	.86	- 28	NJ
Planting Date:					
late May	132	1.32	.66	+ 28	
early May	163	1.63	.86	- 12	IN
Hybrid:					
bottom 5	149	0.99	.60	+ 106	
top 5	250	1.67	.83	- 25	FL
Population:					
low (12,000)	155	1.44	.52	+ 39	
high (36,000)	231	2.14	.96	- 60	FL
Compaction:					
compacted	123	2.46	.62	+ 33	
not compacted	167	3.34	.84	- 17	IN
pH x P:					
low pH, low P	90	----	.60	+ 33	
high pH, high P	138	1.97	.92	- 29	WS
P Placement(in row)					
No P_2O_5	143	----	.64	+ 39	
35 lb P_2O_5	159	4.54	.71	+ 18	
70 lb P_2O_5	165	2.36	.73	+ 11	WS

[1] lb of N applied per acre was less than (-), or more than (+) uptake in above ground portion of crop.

Fertilizer Use on Legumes

Forage legumes grown in rotation with grain crops are an important part of the low-input system. These rotations are also part of many conventional farming systems. To be most effective in supplying N and organic residue, the legume stand must be healthy, vigorous, and high yielding. Adequate levels of P, K, S, magnesium (Mg), and boron (B) are essential for productive legumes. Legumes will be less thrifty in low-input systems which may involve lowered soil test levels resulting from lower annual fertilizer applications. **Table 6** indicates a good example from alfalfa research in Kansas where three year average yields were increased by nearly two tons/A by maintaining soil test P levels with an annual application of 80 lb/A P_2O_5 (Ball et al, 1980).

Table 6. Alfalfa yield as affected by P applications and soil test P levels.

P_2O_5 Rate	3-year Ave. Yield	P Soil Test Level Initial	2nd yr	3rd yr
lb/A	tons/A	---------- lb/A ----------		
0	7.7	19(low)	10	8
40	8.9	19	15	11
80	9.4	19	18	17

Similar results have been obtained from the Pennsylvania Alfalfa Growers Program. **Table 7** shows the average amount of K taken up and soil test K levels from alfalfa produced by the growers in the various yield categories (Lanyon et al, 1983). If forage legumes are to be useful in either conventional or low-input systems, they must be supplied with an adequate and balanced level of nutrients whenever they are found to be limiting by soil or plant testing.

Table 7. Relationship of yield to K uptake and soil test levels found in the Pennsylvania Alfalfa Growers Program.

Yield Group	Uptake	Soil Test Level
tons/A	----------K, lb/A----------	
up to 4	190	363
4 - 5	251	375
5 - 6	293	387
6 - 7	352	399
7 - 8	419	472
over 8	487	544

Data from Pennsylvania Alfalfa Growers Program

Effects of P and K on N Fixation

The process of symbiotic fixation of N is one of the reasons forage legumes are recommended for low-input systems. Research around the world has shown that high and balanced fertilization with P and K is essential for most efficient nodule activity and N fixation (PPI, 1988b). A reduction in P and K use on legumes in low-input systems will have several results:

1. Decreased top and root growth. Anything which restricts root development and activity of a legume reduces the ability of that plant to fix atmospheric N.
2. Increased time needed for developing nodules to become active and of benefit to the host legume.
3. Decreased number and size of nodules and the amount of N assimilated per unit weight of nodule.
4. Decreased percent and total amount of N in the harvested portion of the host legume.
5. Decreased density of *Rhizobia* bacteria in the soil surrounding the root. If adequate density is not achieved, nodulation is impaired.

With N production from legumes such an important factor in the low-input approach, the ability of legumes to effectively and efficiently fix N will be critical. A high level of P and K in either a conventional or low-input system would appear to be of paramount importance, but may not be compatible with low-input recommendations. An example from a field experiment with sweet clover (**Table 8**) shows that most dry matter production, most N per acre, and most N per ton were produced when P and K were included in the annual fertilizer program (Albrecht et al, 1948).

Table 8. Dry matter and N production of sweet clover with different fertility treatments in a four-year rotation of corn, oats, wheat, and sweet clover.

Yield	Lime 2 tons every 8 years	Lime + P_2O_5 120 lb P_2O_5A/yr.	Lime + P_2O_5 + K_2O 120 lb/A/yr both P_2O_5 and K_2O
Dry Matter, lb/A	4,950	9,035	12,190
N, lb/A	92	161	234
N, lb/ton	37	36	39

Fertilizer Use and Organic Residue

A factor which is often cited as favoring more forage legumes and animal manures in low-input systems is increased organic residues in soils. Nitrogen fertilization balanced with adequate levels of P, K and other essential nutrients has a direct influence on dry matter production and the amount of organic residue produced on a farm. For example, in a New York wheat experiment, 2 tons/A of straw were produced from a crop yielding 103 bu/A, but only 1.65 tons/A of straw resulted with a 81 bu/A wheat yield. Examples such as this can be cited from experiments on many crops. Olson (1972) cited a number of experiments where N and P fertilizer were omitted and resulted in substantial first-year yield loss (**Table 9**). A scientific Task Force (CAST, 1980) estimated a 15 to 25 percent drop in crop production with a switch to low-input systems. These examples indicate that a conventional farming system using BMPs, including adequate fertilization, will increase the production of organic residue and enhance the effects of that residue on the soil's productive capacity.

Table 9. Effect of eliminating N and P fertilizer on first-year yield loss from several crops and locations.

Crop Grown	Region in U.S.	Fertilizer Use N	Fertilizer Use P_2O_5	First-year loss without N or P
		------lb/A-----		%
Corn	Iowa	70	40	20
Corn	Illinois	65	38	37
Wheat	Kansas	30	18	11
Rice	Calif.	91	33	49

> *"Size and number of earthworms invariably increase as soils are brought from a low to high level of fertility through effective fertilization."*
> --Dr. R. A. Olson, 1972.

Animal Manures: Availability and Environmental Implications

"There is over a half century of experience and literature from land grant university agricultural experiment stations and other sources that scientifically verify the soundness of such agronomic practices as crop rotations, use of legumes in rotations, use of manures and various organic sources of nutrient supplements. Shifting to other nutrient sources such as manures, legumes, etc. is not without economic and environmental costs, however. If the goal of sustainable agriculture is to reduce off-farm inputs (fertilizer), then obviously nitrogen, phosphorus and potassium inputs must be increased from manures, biological nitrogen fixation, and other sources such as wastes. Since fertilizers now comprise about two-thirds of nutrient additions to U.S. cropland, it is obvious that major additional amounts of nutrients from manures and biological nitrogen fixation must be achieved."--Dr. Fred Miller, Ohio State University, and Dr. Bill Larson, University of Minnesota.

Availability

The following examples show the effects of replacing commercial N with animal manure. The data were calculated from various sources (Bandel, 1988; Barker, 1987; Follett et al, 1987; Kelling, 1988; and Van Dyne and Gilbertson, 1978). Because animal manures are so variable in nutrient content, storage methods, application management, and availability for use on cropland, this scenario is an estimate based on these sources of information. It is estimated there are 1.9 million tons of N available from animal manures annually in the U.S. Manure from one mature dairy animal is equivalent to approximately 60 pounds of available N per year. Therefore, 60 pounds of N equals one Available Animal Nitrogen Unit (AANU). **Table 10** shows the number of some other animals required to equal one AANU.

Table 10. Animals required to equal one AANU.

60 pounds N per year = AANU

Mature Dairy	=	1
Mature beef	=	2.5
Mature swine	=	9
Mature sheep	=	17
Laying hens	=	140
Broilers	=	500

Table 11 indicates the distribution of animal and commercial fertilizer N in the U.S., 12 Corn Belt states, and Iowa. Nitrogen available from animal manure is only 18 percent of the amount of fertilizer N used in the U.S. annually. However, in the 12 Corn Belt states and Iowa, where grain production is the greatest, the percentage of available animal N to fertilizer N used is much lower. Only 34 percent of the available animal N is located in the Corn Belt while 56 percent of total fertilizer N is used in these 12 states. There would have to be a tremendous increase in animal numbers and a huge cost in labor, energy and equipment to get the manure in place for optimum use.

Table 11. Distribution of available nitrogen from manure and commercial fertilizer.

	Total Available N from Manure	Fertilizer N Used	Percent Manure N: Fertilizer N
	(000)tons	(000)tons	%
U.S.	1,900	10,350	18
12 Corn Belt states	643	5,749	11
Iowa	66	852	8

Scientists in Pennsylvania (Pennsylvania State University, 1988) calculated the breakeven distance for hauling 8 tons of solid manure with a nutrient percentage of 10-3-5 (N-P_2O_5-K_2O). The value of the load was $17.12 if the manure was incorporated into the soil within two days, and $13.04 if not incorporated. The hauling costs were $1.78 per mile. The cost of loading and spreading was not considered because it would be the same for any hauling distance. The break-even distance was 9.6 miles if manure was incorporated and 7.3 miles if unincorporated.

> *"Science has clearly documented the amount of nutrients required to produce a certain yield of many of our crops, and the quantities are significant. The total nutrient content of all available sources of manures and composts for both animal and plant origins would be totally inadequate to supply the nutrients required in producing the foods and fiber necessary to sustain our own needs, as well as those of a number of other nations in the world."* -- Tommy Irvin, Commissioner, Georgia Department of Agriculture.

Table 12 gives the number of AANU's required to replace fertilizer N in either the U.S., the 12 Corn Belt states or Iowa. AANUs would have to increase over 5, 8, and 11 times in the U.S., Corn Belt, and Iowa, respectively, to generate enough manure N to replace fertilizer N. To replace just an additional 10 percent of the fertilizer N in the Corn Belt with manure would require almost a doubling of AANUs. In Iowa, if an extra 10 percent of fertilizer N was replaced with beef animals, it would require over 7 million head to supply this N--three times the current number in the state. If beef animals consumed an average of 15 bushels of corn per head per year, it would require an additional 900,000 acres of corn just to feed the extra beef animals (assume 120 bu/A yield). That does not include additional acres necessary for forages. Or, if they were maintained exclusively on pasture at a stocking rate of 7 per acre, another one million acres would be needed. In that case, the manure would not be used for grain crops. It is obvious that to replace any significant amount of fertilizer N with manure would have a major negative impact on the economies of both the animal and grain industries.

Environmental Consequences

Addiscott (1988) summarized the research from the Rothamsted Experiment Station in England over the past century and concluded that all the N that becomes available to crops is also vulnerable to leaching as nitrate. It makes no difference whether this nitrate originates from a commercial fertilizer, organic matter sources, or from the breakdown of organic matter in the soil. Addiscott observed nitrate leakage from a pool of decomposable N in arable soils which breaks down slowly with time. He suggests that scientists should expect to find some base level of nitrate in soils at any one given time. **Researchers have found that while animal manure can be at least as effective as commercial fertilizer in improving yields, it is also more of a pollution risk.** This is because plots receiving manure regularly contain more nitrate in the soil after harvest in the autumn than plots receiving commercial fertilizer. There is more organic N for microbes to break down, coming from both past and current year additions of manure.

Minnesota researchers (Randall, 1989) reported that the use of liquid hog manure resulted in soil nitrate concentrations higher than when anhydrous ammonia was the N

Table 12. Current AANU's and increases required to replace fertilizer N

	Current AANU	Additional AANU Needed to Replace All Fertilizer N	Percent Increase in AANU needed to Replace fertilizer N
	(000) units	(000) units	%
U.S.	63,333	345,000	545
Corn Belt	21,433	182,633	850
Iowa	2,200	26,200	1,190

Table 13. Corn yield and nitrate concentration in soil water as influenced by N treatments.

N Form	N Rate lb/A	Time Applied	2-Yr. Ave. Yield, bu/A	Nitrate Content in Soil Water, ppm[2]
Anhydrous Ammonia	150	Spring	177	12
Anhydrous Ammonia	75 + 75	Spring + Sidedress	173	10
Hog Manure	196[1]	Spring	184	41

[1] Estimated available N. Total N applied was 315 lb/A, half being inorganic and half organic. Researchers assumed 100 percent availability from inorganic N in year of application.

[2] Measured at 5-foot depth by suction lysimeters at end of second year.

Minnesota

source. Although N rate provided by the manure was 46 lb/A higher than that from the anhydrous ammonia, the difference was not enough to account for the wide variance in soil nitrate contents (**Table 13**).

After two years of the study, the researchers note: "Realistic applications of liquid hog manure resulted in...highest corn yields, but very high NO_3-N concentrations in the soil water."

Bertilsson (1988) studied leaching losses from N rates and manure applications. He found nitrate leaching was more dependent on conditions after harvest than on N application rates. Manure applications in the fall resulted in largest nitrate losses. Such losses could be reduced by a cover crop such as rape.

Fraser et al (1988) compared organic N (beef feedlot manure) with fertilizer and fertilizer plus herbicide treatments applied to a four-year corn/legume crop rotation. The potentially mineralizable N levels in the surface 0 to 3-inch soil layer were significantly greater in the organic farming system than with conventional fertilizer or fertilizer plus herbicide treatments.

Potentially mineralized N in manure-amended surface soils (0-3 inches) was 22 to 44 percent greater than nonmanured soils receiving fertilizer and fertilizer and herbicides.

Ellis (1988) concluded in a recent review of the subject that it was clear that all sources of N can be associated with the passage of nitrate to depths below the rooting zone of crops. He cited the relative contribution of various management systems to nitrate in soil water. Although the data shown in **Table 14** were taken from different studies and sampled in different years in some cases, they do illustrate the fact that manure and alfalfa, plowed down, also can contribute significantly to soil profile nitrate.

Table 14. Nitrate levels at 5-foot depth under growing corn.

Management Practice	Nitrate Content of Soil Solution parts per million (ppm)
No N, no irrigation	8.4
N, no irrigation	10
N, irrigated	25
Manure N, no irrigation	49
Alfalfa N, no irrigation	62

Measured by suction lysimeters. Michigan
Alfalfa measurement taken in year of plowdown.

Concentrated animal production areas, such as southeast Pennsylvania, have specific environmental problems where animal number exceeds the land's ability to support the system. As a result, feed must be imported and manure management becomes difficult. Lanyon et al (1987) studied nutrient loading on small dairy farms in Pennsylvania watersheds which feed into the Chesapeake Bay. One typical farm had 102 cultivated acres and 60 dairy cows. Sources of input and output for N, P and K over the course of one year are shown in **Table 15**.

Table 15. Nutrient input and output on a dairy farm in Southeast Pennsylvania.

	N	P	K
		lb/year	
Input:			
Total farm cropland(102 acres)	20.749	5.067	16.529
From fertilizer	902	977	514
From manure	19.847	4.090	16.015
Purchased feed	12.884	2.494	3.413
Output:			
Removed in crops	20.407	3.195	17.856
Balance (in-out)	342	1.872	-1.327

There were only 902 lb of N purchased as fertilizer while 19,847 and 12,884 lb of N came from animal manure and purchased feeds, respectively. Dr. Lanyon says, "The major role of purchased feeds in contributing nutrients to these small farms is apparent."

Farmers who might switch to low-input systems would be faced with these problems:

1. The energy required to manufacture, transport and apply plant nutrients from commercial fertilizer is equivalent to that required to haul and spread an equal amount of plant nutrients in manure to a distance of about one mile (Heichel,1976). Economics favor commercial fertilizer when the costs of transporting manure more than a few miles are considered.
2. Commercial fertilizers are the most controllable source of nutrients for crop production. Through judicious selection of rates, placement, sources, and application times it is possible to supply nutrients reasonably close to the economically optimum level. By contrast, it is difficult to fine-tune the amount, or timing, of N release from animal manure, forage legumes, or other types of organic wastes (Fixen, 1985). This difficulty increases environmental risk.
3. Animal manures and sewage sludges, as sources of plant nutrients, are bulky, low-grade organic materials of variable composition. The total plant nutrient content is only 10 to 20 percent of that of most commercial fertilizers. The potential for soil compaction is greater with animal manures and sewage sludge because of the heavier loads required to obtain the same nutrient input. This increases the potential for runoff to streams, thereby contributing not only nutrients but biochemical oxygen demand (BOD) loads and microbial contamination (Singer and Munns, 1987).

   Concentrations of nutrients, soluble salts, micronutrients and water vary tremendously in animal manures and sewage sludge. In addition, sewage sludge often contains heavy metals, such as cadmium, that are retained in soils and can be toxic to plants, animals and man (CAST, 1975).
4. Optimum rates of manure and sewage sludge applications are difficult to predict (CAST, 1975). **Table 16** shows the variability in nutrient content from two manure analysis labs (Bandel, 1988; and Barker, 1987). This variability illustrates the difficulty in applying appropriate rates for yield and environmental considerations. It also emphasizes the extreme importance for a waste management testing service for all animal manure and sewage sludge going on crop land. Some of the greatest known environmental problems associated with agriculture have been with the storing and distribution of animal manures.

Table 16. Manure nutrient characteristics of dairy and poultry manure

	Nitrogen	P_2O_5	K_2O
		lb/ton	
Dairy Manure			
paved lot			
scraped (N.C.)	4 to 12	1.6 to 8.6	2 to 13
solid (Maryland)	4 to 14	1.2 to 8.9	1 to 15
Poultry			
North Carolina	15 to 40	14 to 30	7 to 16
Maryland	4 to 136	10 to 111	1 to 79

5. Farmers in a mixed grain-livestock system who do not use N fertilizers and pesticides will have an estimated 15 to 25 percent reduction in grain crop yields. There would also be a major reduction in grain acres as legumes would be added in rotation with grain to provide part of the N requirement. Lower yields and reduced acreage would

significantly reduce the amount of grain produced in any given year (CAST, 1980). It has been estimated that for each one percent decrease in crop production, there would be a one to 5 percent price increase depending upon the type of crop and this translates into higher food costs (CAST, 1980). Or, there would be more acres planted to maintain production, but on soils with much greater environmental risks.

6. Research indicates that conventional and low-input systems do not differ greatly in their effects on soil organic matter. In general, conventional farming probably adds more organic matter than organic farming because crop residue production is greater (CAST, 1980).
7. Changing conventional cash grain farms to low-input grain/livestock farms does not result in a net addition of plant nutrients unless feed or manure is imported from off the farm, which would impoverish some other land (CAST, 1980). **Low-input systems, like conventional systems, result in a net loss of nutrients from the farm when products are sold off the farm.**
8. Total fertilizer use per harvested crop acre in the U.S. has been relatively stable over the past decade (See **Table 2**). This is contrary to the perception that conventional farmers over fertilize to take advantage of government programs and thus contribute more and more to possible environmental problems. The 25 percent of the farmers who produce 75 percent of the agricultural products are generally economically efficient, or they would not remain in business. Sound agronomic plans geared to realistic yield goals are BMPs which actually help protect the environment. Healthy crops with balanced fertility not only produce high crop yields, but also high levels of crop residue (roots, stalks, leaves, etc.) which help hold soil in place, conserve moisture, and reduce runoff.

   There is no "free lunch" when it comes to maintaining soil supplies of nutrients such as P and K. The amounts removed in harvested crops or through animal products must be replaced or soil fertility and soil productivity will decline.
9. With a large-scale switch to low-input systems there would be a major shift in agricultural production and the economics of that production. Crop acres would decrease and animal numbers would increase. There would also be a geographical change in the distribution of livestock, with more being needed in the major grain producing areas. Management and labor requirements on the new grain/livestock farms would change. Farmers with cash grain expertise would have limited animal management knowledge. Mistakes could be costly both economically and environmentally. Labor intensive, low-input systems would entail difficult adjustments and social costs for many individuals (CAST, 1980).

❧ Forage Legumes: Economic and Environmental Consequences

Concerns over the cost of fertilizer N and the increased emphasis on conservation tillage have stimulated many agronomists to research the possibility of using legumes as a cover crop (Frye, 1988; Hesterman, 1988). These studies show that legumes can provide some of the N to the succeeding grain crop and provide a good cover to improve water efficiency and erosion control in conjunction with conservation tillage practices. Annual legumes seeded in the fall and killed prior to seeding the grain crop in the spring can be used to provide some of the N requirements for the non-legume crop. In the northern areas, especially the northern Corn Belt, perennial legumes grown for a full season in rotation with corn are needed if significant amounts of fertilizer N are to be replaced. Approximately 40 percent of the corn acreage (24 million acres) would fall into this category.

Rotating perennial legumes with a grain crop is given major emphasis in low-input systems. A rotation which includes a forage legume fits into the overall scheme of low-input practices where cash grain farms are to be diversified to include livestock.

Economic Considerations

The practice of rotating a forage legume with a non-legume crop will result in fewer acres of the non-legume in any one year. For example, assuming an average yield of 120 bu/A corn in the northern Corn Belt there would be 1.2 billion less bushels of corn produced in that area if the acres were cut in half. This would mean a $3.3 billion loss to the farm economy (corn price, $2.75/bu). If more land were used to maintain corn production levels, these acres would be more subject to erosion and environmental risk.

In the above example, some value should be assigned to the forage legume in the rotation. However, any large increase in legume acreage will upset the supply/demand balance for hay and curtail the ability of low-input farmers to sustain a profitable forage component in the system.

Later planting is commonly mentioned as an essential component of low-input systems. This concept assumes that by letting early-germinating weeds grow to sufficient size they can be more easily controlled with cultivation, thereby lessening the need for pesticides. Early planting is essential to profitable corn production. Although corn performance may be improved in some seasons by postponement of planting operations until soil and weather conditions are ideal, years of testing nationwide consistently show that corn planted early is superior to that planted late (Anderson and Wagger, 1987; PPI, 1988a). A yield loss of 1.5 bu/A/day is common in the Corn Belt when planting is delayed past the optimum date for that location. A delay in planting corn to allow legumes to fix more N, or to allow a cultivation of weeds, is not a BMP. For 100 acres of corn, to delay planting 10 days past the BMP date for that location would mean a potential loss of 1,500 bu and over $4,000 with corn at $2.75/bu.

Environmental Considerations

One of the prime reasons for including forage legumes in rotation with non-legume crops in low-input systems is the contention that legumes will reduce the need for fertilizer N and minimize nitrate losses to groundwater, the perception being that legumes do not release nitrate to groundwater. Russelle and Hargrove (1989) have written an excellent review and have summarized research conducted on this topic. Their concluding paragraphs state:

*"**Nitrate leaching hazard associated with organic sources of N such as animal manures or legumes can be significant.** Successful use of these N sources to supply adequate N to a growing crop while minimizing losses requires equally careful management as with inorganic N sources. Simply replacing fertilizer N with these sources will not ensure a reduction in nitrate leaching. Estimates of the mineralization rates of these sources are needed in order to ensure timely application of appropriate rates. Organic-N sources often result in larger amounts of residual soil-N after cropping than fertilizer N sources. Management practices such as cover cropping with a non-legume to remove some residual N might be appropriate in many situations.*

"Best management practices for low-input systems are evolving, but to minimize ground water contamination, they will require equal, if not greater, levels of management compared to fertilizer N based production systems. In the final analysis, development of management strategies that satisfy both ecological and economic concerns will support a vigorous, sustainable agriculture system."

In **Table 14**, shown earlier, Ellis (1988) reported relatively high nitrate levels where alfalfa had been plowed down in the spring and planted to corn. He stated, *"The control of quantity and time of application of N from natural sources such as alfalfa and manure is more difficult to manage than when using fertilizer."*

Selected references from the review by Russelle and Hargrove (1989) are given along with brief summaries of the reported results. Their review leaves little doubt that legumes have a considerable potential to leach nitrate to groundwater. The authors suggest that a great deal more research is needed to understand the mechanisms by which this nitrate is lost and the management strategies to minimize the losses.

Groffman et al (1987) compared 85 lb/A fertilizer N with a rye cover crop to crimson clover with no fertilizer N. Nitrate was found under both systems at the various sampling dates and significantly more nitrate from the crimson clover treatment was found in the spring.

Hargrove (1984 and 1986) noted greater nitrate leaching potential from a legume cover crop system compared to a fertilizer N system with either a rye cover crop, or no cover. The nitrate levels at the end of the summer growing season were greater with the legume cover system.

Addiscott (1988) reported that potential leakage during the winter months may be substantial. Precipitation exceeds evaporation, so water flows downward after harvest or when slow growth of fall seeded plants requires only small amounts of N.

Goh et al (1979) found nitrate leaching losses in New Zealand were greater under legume-grass pastures than with either wheat or fallow conditions.

Low and Armitage (1970) found 27 lb/A N leached from established white clover compared to about 2 lb/A under a non-fertilized meadow fescue. They also observed that nitrate losses increased sharply as white clover populations declined over time. Russelle (personal communication) states that several scientists suggest that one of the primary contributions of nitrate to soils is when legume roots, nodules, etc. die. He has calculated an enormous number of alfalfa plants that would die in the normal life of an alfalfa field.

Jones et al (1977) found 24 lb/A more nitrate losses under subterranean clover than under non-fertilized soft chess.

Robbins and Carter (1980) observed 39 lb/A nitrate losses under an established alfalfa stand in Idaho.

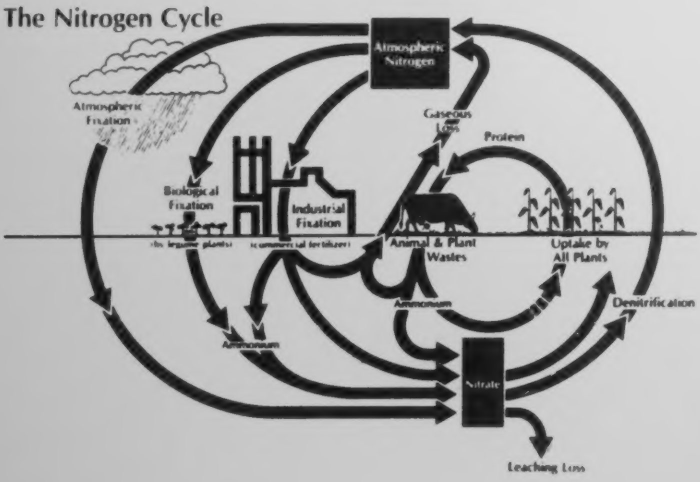
Losses of nitrate presumably derived from N fixation can be very large after the legume is killed (Russelle and Hargrove, 1989). Low and Armitage (1970) removed clover plants and observed over 115 lb/A nitrate in drainage lysimeters. Ladd et al (1986) found greater nitrate accumulation in the upper 24 inches of soil following incorporation of a legume compared to wheat or legume-grass pasture.

Summary of Factors Affecting Nitrates in Groundwater

It is obvious that all N sources, both organic and inorganic, have the potential to generate nitrate which can leach into groundwater. To change farming practices from conventional to low-input systems in order to diminish the leaching of nitrates has little scientific basis. The N cycle in soil is a dynamic, continuous process. The process was going on long before intensive grain crop production began. Even some of the N released today may be at some constant base level from N fixed or captured and immobilized many years ago.

Long-term studies at Rothamsted have shown that most of the nitrate leaching does not come directly from the applied N source, but from the organic matter and the immobilization/mineralization of residues returned to the soil (Powlson, 1988). Wheat straw, corn stalks, cover crop residue, and other materials become a part of the dynamic N cycle process. **Nitrogen which becomes available from these sources and is unused by a growing crop will be subject to leaching. Temperature, rainfall, carbon:N ratios in soil, cropping sequences, and many other factors play a role in the N cycle processes.**

Scientific facts do not support a switch to low-input systems (where legumes and animal manures replace commercial fertilizer) on the basis that nitrates in groundwater will be reduced. With this fact, and the need to maintain a stable source of food for the world, it seems prudent to continue the tradition in the U.S. of developing conventional BMPs through research and implementing the results through extension programs. **A policy change that encourages farmers to use low-input systems without the scientific basis of today's conventional systems will not help the environment and could seriously jeopardize the ability of the U.S. to remain a reliable source of food, feed and fiber.**


The Nitrogen Cycle
Atmospheric Nitrogen
Atmospheric Fixation
Gaseous Loss
Protein
Biological Fixation
Industrial Fixation
(by legume plants)
(commercial fertilizer)
Animal & Plant Wastes
Uptake by All Plants
Ammonium
Denitrification
Ammonium
Nitrate
Leaching Loss

❧ Best Management Practices (BMPs)

The economic viability and environmental soundness of agricultural production will best be served through research, education, and government programs which encourage all farmers to use BMPs for every controllable input from seeding to harvest and from soil fertility management to soil conservation practices. When BMPs for soil and water conservation practices are combined with those for agronomic practices, the most efficient and profitable production system will be achieved. In addition, efforts to implement current BMPs and develop better ones will be the least costly to our government and the American people. As BMP systems are more widely adopted, potential production per acre is increased. This provides flexibility to release, or set aside, the more environmentally sensitive areas of a farm or field and at the same time control crop production at the desired level. Ten factors associated with BMPs are:

1. BMP technology should be based on research results.
2. BMP programs should be continually improved through research and the implementation of the research.
3. BMP programs encourage farmers to be good crop managers.
4. BMP programs include both soil and water conservation and agronomic practices.
5. BMP programs have a high input efficiency.
6. BMP programs are farm, soil, and crop specific.
7. BMP program adoption depends on strengthening the educational phases of agriculture.
8. BMP programs provide flexibility to maintain crop production at desired levels.
9. BMP programs provide flexibility to release the most sensitive environmental risk acres on a farm.
10. BMP programs are most successful when crop production and conservation practices are integrated into a package proven best for that location. The more proven practices adopted the greater the expected success.

Appendix A (following) presents examples of crop production situations, in diverse geographic areas, with indications of possible benefits of BMPs.

Appendix A

Following are examples of specific crop production situations which illustrate the potential benefits of BMPs.

BMPs for Corn (Grain) Production in Northcentral Iowa

BMPs for Hard Red Winter Wheat in Kansas

BMPs for Irrigated Lint Cotton Production in the Mississippi Delta

BMPs for Soft Red Winter Wheat in Virginia

BMPs for Hard Red Spring Wheat in the Northern Great Plains

BMPs for Soybeans in Southeast Indiana

BEST MANAGEMENT PRACTICES (BMPs) for CORN (GRAIN) PRODUCTION IN NORTHCENTRAL IOWA

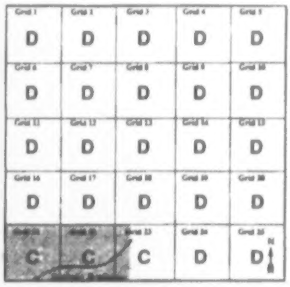
Data for this example.

Field size:	100 acres	Average corn yield for this soil:	150 bu/A
Land description:	Clarion-Nicollet-Webster. A Class One soil, very gently rolling with slight surface drainage waterways.	Current corn grain yield for this farmer:	150 bu/A

Selected Soil and Water Conservation BMPs:

Factor	Current Practice	Recommended BMP	Environmental Advantages
Tillage	Fall chisel	Ridge-plant	Water efficiency; less soil erosion
Compaction	Moderate	Only in controlled wheel tracks.	Water infiltration; nutrient efficiency
Land environmental impact rating	None	Yes (see map)	

Note: The map at right represents a 100 acre field. A soil and water conservation plan should include a rating of the land as to its vulnerability to environmental pollution. This rating can be done on a grid basis (see map) so that those acres most vulnerable to erosion and water pollution can be released (set-aside) first as farmers adopt BMPs. In many situations, the erodible land is the least productive. It can be released from cropping without reducing total production on the individual farm.



Grid 1 D	Grid 2 D	Grid 3 D	Grid 4 D	Grid 5 D
Grid 6 D	Grid 7 D	Grid 8 D	Grid 9 D	Grid 10 D
Grid 11 D	Grid 12 D	Grid 13 D	Grid 14 D	Grid 15 D
Grid 16 D	Grid 17 D	Grid 18 D	Grid 19 D	Grid 20 D
Grid 21 C	Grid 22 C	Grid 23 C	Grid 24 D	Grid 25 D

Environmental Impact Rating:

Designation	Rating	Grid Numbers
A	Very Severe	none
B	Severe	none
C	Moderate	21, 22, 23
D	Slight	all others

▨ **Indicates Potential Release Acres (9) When BMP Management Is Used On Remaining Acres.**

Selected Agronomic BMPs:

Factor	Current Practice	Recommended BMP	Environmental Advantages
Plant population	23,000/A	27,000/A	Nutrient and water efficiency
Planting date	April 28 to May 8	April 26 to May 3	Earlier ground cover
Hybrid maturity	105-day	115-day	Higher yield potential
Weed control	Preplant incorporated, full rate	Band apply grass herbicide; scout and use only if needed	Less chemical used
Disease control	None	Scout; limited need with ridge-plant	Chemicals used only as needed
Nitrogen (N) Management			
Soil test	No	Soil nitrate test 6 ppm NO_3-N, 0-1 foot	N efficiency
Rate*	135 lb/A	130 lb/A	Less N used
Timing	All preplant broadcast	25 lb/A starter, 105 lb/A point-injected at V6 growth stage	Greater N efficiency and less subject to loss

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* N credits from manure would be substituted whenever available. Legume N credits have been used for soybeans in both cases.

(see other side)

Factor	Current Practice	Recommended BMP	Environmental Advantages
Phosphorus (P) Management			
Soil test	Yes-high	Yes-high	
Rate, timing	60 lb/A, broadcast in spring	35 lb/A fall, 25 lb/A band starter	Better efficiency of P and other inputs
Potassium (K) Management			
Soil test	Yes-high	Yes-high	
Rate, timing	50 lb/A , broadcast in spring	35 lb/A fall, 15 lb/A band starter	Better efficiency of N and P
Sulphur (S) Management			
Soil test	No	Yes, but not common	
Rate, timing	None	Application in starter, by soil test and/or plant analysis	Better early growth; efficiency of N and P
Micronutrients			
Soil test	No	Yes, but deficiencies uncommon	
Nutrient, rate	None	Where indicated by soil test, 1-2 lb/A zinc in starter	Enhanced plant growth; efficiency of other nutrients

Note: BMPs already used in current practice are: rotation with soybeans; P and K soil tests; scouting for insects; drainage tile; and good soil pH level.

Results and Summary:

This example is for northcentral Iowa, on a very productive soil. In this example, the management is good, but can be improved with further adoption of several BMPs as indicated above. Yield potential could be increased 10 to 15% which gives the farmer flexibility to release acreage most environmentally sensitive (see map on other side). The implementation of BMPs also increases nutrient efficiency and water use efficiency. The table below summarizes some of the advantages for adoption of BMPs.

Approximate Effects of BMPs on Yield*

Ridge-plant and starter fertilizer	5 to 9 bu/A
Earlier planting of longer season hybrid	5 to 7 bu/A
Increase population	3 to 7 bu/A

*Estimated yield increases are not necessarily additive. Interaction effects with other inputs can change the response. The responses shown are averages from various research trials where these inputs were investigated.

Possible Advantages of BMP Program for Corn (Grain) Production in Northcentral Iowa

Factor	Current Practice	Recommended BMP
Expected yield, bu/A	150	165
Acre release potential from 100 acres to maintain same production	----	9
Total production		
with 100 acres, bushels	15,000	----
with 91 acres, bushels	----	15,015
Phosphorus efficiency, bu/lb	2.5	2.8
N efficiency, bu/lb	1.1	1.3
N remaining (most in residue), lb/A	60	40
Total N applied, lb	13,500 (100 acres)	11,830 (91 acres)
Total N remaining (most in residue), lb	6,000 (100 acres)	3,640 (91 acres)
Water use efficiency, bu/inch	7.0	7.7
Production costs, $/A	330	350
Production costs, $/bu	2.20	2.12
Production costs for field		
100 acres, $	33,000	----
91 acres, $	----	31,850
Profit, $/field 100 acres	4,500	----
91 acres	----	5,687

NOTE: BMP adoption allows this farmer to release land with the highest degree of sensitivity to environmental factors (see map on other side) and maintain, or improve, total farm production.

Basis for calculations:
Iowa State University . Corn price at $2.50/bu.

Prepared by agronomists of the Potash & Phosphate Institute (PPI) based on research and extension demonstration information from Iowa State University and University of Minnesota.

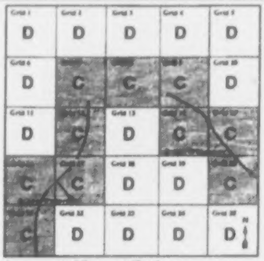
BEST MANAGEMENT PRACTICES (BMPs) for HARD RED WINTER WHEAT IN KANSAS

Data for this example.

Field size:	100 acres	Average wheat yield for this soil:	31 bu/A
Land description:	Harney silt loam. A Class One productivity soil in the central dryland region of Kansas.	Current wheat yield base for this farmer:	31 bu/A

Selected Soil and Water Conservation BMPs:

Factor	Current Practice	Recommended BMP	Environmental Advantages
Terraces	Partial	Complete	Slows water run-off; less soil erosion
Grass waterways	None	Install grass waterways	Less soil loss from surface drain areas (see map)
Tillage	Disk-sweep, clean till	Chemical fallow-sweep	Reduce soil erosion; increase water infiltration
Wind erosion	No control, except emergency chisel	Adequate surface residue from chemical fallow	Reduce soil loss due to wind
Land environmental impact rating	None	Yes (see map)	



Environmental Impact Rating:

Designation	Rating	Grid Numbers
A	Very Severe	none
B	Severe	none
C	Moderate	7,8,9,12,14,15,16,17,20,21
D	Slight	all others

▨ Indicates Potential Release Acres When BMP Management Is Used On Remaining Acres.

NOTE: The map at right represents a 100-acre field. A soil and water conservation plan should include a rating of the land as to its vulnerability to environmental pollution. This rating can be done on a grid basis (see map) so that those acres most vulnerable to erosion and water pollution can be released (set-aside) first as farmers adopt BMPs. In many situations, the erodible land is the least productive. It can be released from cropping without reducing production on the individual farm.

Selected Agronomic BMPs:

Factor	Current Practice	Recommended BMP	Environmental Advantages
Certified seed	Bin-run seed	Use certified seed	Quicker emergence
Variety	Old standard (tall-type)	Best semidwarf in tests	Quicker ground cover
Row-spacing	12-inches	10-inches or 6/14 paired rows	Uniform ground cover
Seeding rate	60 lb/A	Precision planting 280-290 seeds/sq. yard	Earlier cover to protect soil
Rotation	Wheat-fallow-wheat	Sorghum-fallow-wheat	Less pest pressure
Weeds	Occasional spring spray	Chemical fallow, scouting for spring spray	Less soil erosion; chemicals used only when needed; conserve moisture
Diseases	Seed treatment	Seed treatment plus scouting for foliar disease thresholds; potassium chloride (KCl) fertilizer.	Chemicals used only when needed
Nitrogen (N) Management*			
Soil test	None	Soil nitrate test 7 ppm NO_3-N= 56 lb/A 2 feet	N efficiency
Rate	60 lb/A, no basis	100 lb/A based on yield goal and nitrate test	N efficiency
Timing	All preplant	Split: 40 % preplant; 10% at seeding; 50% at tillering	N efficiency

*If animal manure is available for use as a nutrient source, it should be analyzed for N content, applied prior to seeding and incorporated by tillage. The amount of N available from manure would be taken into account in recommendations for preplant N applications. Soluble salt accumulations from manure should be closely monitored under dryland conditions. The practicality of manure use would also be affected by choice of tillage system.

(see other sid

Factor	Current Practice	Recommended BMP	Environmental Advantages
Phosphorus (P) Management			
Soil test	None	15 ppm Bray P-1	
Rate, timing	None	45 lb/A P_2O_5 to build to high soil test level; apply at seeding	Early ground cover
Potassium (K) Management			
Soil test	None	250 ppm (high)	
Rate, timing	None	35 lb/A K_2O as KCl; apply at tilier with N	Reduces chemical input needs; chloride helps disease control
Sulphur (S) Management			
Soil test	None	4 ppm SO_4-S	
Rate, timing	None	20 lb/A S, topdressed with N and K	N, P efficiency

Results and Summary:

This example is for the central dryland wheat belt in Kansas. Current practices would produce yields in the 30 to 35 bu/A range. Farmers adopting BMPs as outlined would increase the yield potential to the 60 bu/A range. The yield advantage for BMP production provides flexibility to release acreage most environmentally sensitive (see map on other side) and still maintain current total production potential. It would also provide flexibility to increase total production when demand warrants. The implementation of BMPs also increases nutrient efficiency and water use efficiency, while reducing soil erosion potential. The table below summarizes some of the production, environmental and economic advantages of a BMP Program.

Approximate Effects of BMPs on Yield*

Use of certified seed:	4-8 bu/A increase over bin-run seed.
Better weed control:	4-20 bu/A increase over current practice.
Improved fertilizer mgm't.:	8-20 bu/A increase over current practice.
Improved water storage:	5-12 bu/A increase over current practice.
Erosion control:	3-10 bu/A increase over current practice.
Disease control:	2-18 bu/A increase over current practice

*Estimated yield increases are not necessarily additive. Interaction effects with other inputs can change the response. The responses shown are averages from various research trials where these inputs were investigated.

Possible Advantages of BMP Program for Hard Red Winter Wheat Production in Kansas

Factor		Current Practice	Recommended BMPs
Expected yield, bu/A		35	60
Actual yield, bu/A		31	58
Acre release potential from 100 acres to maintain same production		----	46
Total production:			
	with 100 acres, bushels	3,100	----
	with 54 acres, bushels	----	3,132
N rate, lb/A		60	100
N efficiency, bu/lb		0.51	0.58
(Higher protein also results with BMP system.)			
N removed in the grain, lb/A		36	79
N remaining (most in residue), lb/A		24	21
Total N applied, lb		6,000 (100 acres)	5,400 (54 acres)
Total N remaining (most in residue), lb		2,400 (100 acres)	1,134 (54 acres)
Water use efficiency, bu/in		2.6	4.2
Production costs, $/A		130	175
Production costs, $/bu		4.19	3.01
Production costs for field			
	100 acres, $	13,000	----
	54 acres, $	----	9,450
Profit, $/field	100 acres	-1,375 (loss)	----
	54 acres	----	+3,234

NOTE: BMP adoption allows this farmer to release land with the highest degree of sensitivity to environmental factors (see map on other side) and to maintain, or improve, total farm production.

Basis for calculations: Kansas State University. N, $0.20/lb; P_2O_5, $0.22/lb; K_2O, $0.12/lb; S, $0.20/lb. Additional harvest charge, $0.25/bu. Fungicide, $8.00/A. Value of wheat: current practice, 11.0% protein, $3.75/bu; BMP practices, 13.0% protein, $4.05/bu.

Prepared by agronomists of the Potash & Phosphate Institute (PPI) based on research and extension demonstration information from Kansas State University.

BEST MANAGEMENT PRACTICES (BMPs) for IRRIGATED LINT COTTON PRODUCTION IN THE MISSISSIPPI DELTA

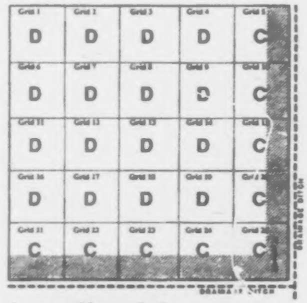
Data for this example.

Field size:	100 acres	Average lint cotton yield for this soil:	800 lb/A
Land description:	Well drained sandy loam soil with good surface drainage.	Current lint cotton yield for this farmer:	800 lb/A

Selected Soil and Water Conservation BMPs:

Factor	Current Practice	Recommended BMP	Environmental Advantages
Grass drainage ways	None	Yes	Grass drainage way across end rows to drainage ditch.
Land environmental impact rating	None	Yes (see map)	

NOTE: The map at right represents a 100-acre field. A soil and water conservation plan should include a rating of the land as to its vulnerability to environmental pollution. This rating can be done on a grid basis (see map) so that those acres most vulnerable to erosion and water pollution can be released (set-aside) first as farmers adopt BMPs. In many situations, the erodible land is the least productive. It can be released from cropping without reducing total production on the individual farm.



Environmental Impact Rating:

Designation	Rating	Grid Numbers
A	Very Severe	none
B	Severe	none
C	Moderate	5, 10, 15, 20, 21 - 25
D	Slight	all others

▨ Indicates Potential Release Acres When BMP Management Is Used On Remaining Acres.

Selected Agronomic BMPs:

Factor	Current Practice	Recommended BMP	Environmental Advantages
Tillage	Disking; fall subsoiling; several diskings in fall and winter	Fall subsoiling; spring disking	Fuel savings; less particulate matter in atmosphere; erosion control
Seeding rate	70,000/A	55,000/A	Better root and plant growth
Variety	Older standard	Best in comparison test	Greater input efficiency
Nitrogen (N) management	80 lb/A in one application	100 lb/A with 30-40 lb/A in starter, 60-70 lb/A sidedress, depending on soil and/or plant nitrate tests	Greater N efficiency
Lime and pH	No soil test, no lime applied, pH in 5.5 range	Soil test and apply lime to bring pH to 5.8	Improves nutrient efficiency
Phosphorus (P) and potassium (K) management	No soil test to guide P and K application; very little applied	P and K fertilization according to soil test; 80 lb/A K_20 rate on medium soil test, 120 lb/A on low soil test	Improved crop growth; less water runoff; improved lint quality; improved disease resistance
Sulphur (S) and micronutrients	No soil test or plant analysis for guidance; none applied	Apply S, boron (B), and other micronutrients according to soil test and/or plant analysis	Groundwater protection; improved economics for sustainability
Crop protection	Broadbased pesticide use	Crop protection based on field scouting and other diagnostic techniques	Improved N efficiency; groundwater protection; improved productivity; improved crop quality

(see other side)

Results and Summary:

This example is for an excellent soil in the Mississippi Delta region. Current practices would produce lint cotton yields in the 800 lb/A range. Farmers adopting BMPs shown above would increase yield potential to the 1,100 lb/A range. The yield advantage for the BMP production would provide the flexibility to release acreage most environmentally sensitive (see map on other side) and still maintain current total production potential. It would also provide flexibility to increase total production when demand warrants. The implementation of BMPs increases nutrient efficiency and water use efficiency, while reducing soil erosion potential. The table below summarizes some of the production and environmental advantages of a BMP Program.

Approximate Effects of BMPs on Yield*

Seeding rate:	150 lb/A increase over current practice
Variety:	150 lb/A increase over current practice
Fertilizer management:	250 lb/A increase over current practice.

*Estimated yield increases are not necessarily additive. Interaction effects with other inputs can change the response. The responses shown are averages from various research trials where these inputs were investigated.

Possible Advantages of BMP Program for Irrigated Lint Cotton Production in the Mississippi Delta

Factor		Current Practice	Recommended BMP
Expected yield, lb/A		800	1,100
Acre release potential from 100 acres to maintain same production		----	27
Total production:	with 100 acres, lb/A	80,000	-----
	with 73 acres, lb/A	----	80,300
N rate, lb/A		80	100
N efficiency, lb lint/lb N		8	11
N removed in cotton, lb/A		52	71
N remaining (most in residue), lb/A		28	29
Production costs for field,	$/A	$400	$500
	$/lb lint	$0.50	$0.45
Profit, $/field	100 acres	$16,800	----
	73 acres	----	$20,513

NOTE: BMP adoption allows this farmer to release land with the highest degree of sensitivity to environmental factors (see map on other side) and maintain, or improve, total farm production.

Basis for calculations: N, \$0.20/lb; K_2O, \$0.12/lb; lime, \$10/A; harvest, \$0.10/lb; seed, \$0.60/lb; cotton, \$0.71/lb.

Prepared by agronomists of the Potash & Phosphate Institute (PPI) based on research and extension demonstration information from the University of Arkansas and Mississippi State University.

BEST MANAGEMENT PRACTICES (BMPs) for SOFT RED WINTER WHEAT IN VIRGINIA

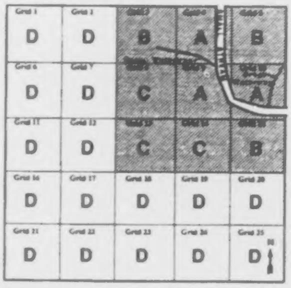
Data for this example.

Field size:	100 acres	Average wheat yields for this soil:	45 bu/A
Land description:	Moderately rolling Piedmont soil with small stream through one corner (see map).	Current wheat yield base for this farmer:	50 bu/A

Selected Soil and Water Conservation BMPs:

Factor	Current Practice	Recommended BMP	Environmental Advantages
Terraces	None	Install terraces	Slow water run-off near stream; decrease soil erosion
Grass waterways	None	Install grass waterways	Grass waterway along stream to slow erosion and water movement
Tillage	Conventional	Minimum-till	Reduce soil erosion, increase water infiltration and reduce soil compaction
Land environmental impact rating	None	Yes (see map)	Identifies for farmer most sensitive environmental area in field

NOTE: The map at right represents a 100-acre field. A soil and water conservation plan should include a rating of the land as to its vulnerability to environmental pollution. This rating can be done on a grid basis (see map) so that those acres most vulnerable to erosion and water pollution can be released (set-aside) first as farmers adopt BMPs. In many situations, the erodible land is the least productive. It can be released from cropping without reducing total production on the individual farm.



Environmental Impact Rating:

Designation	Rating	Grid Numbers
A	Very Severe	4, 9, 10
B	Severe	3, 5, 15
C	Moderate	8, 13, 14
D	Slight	all others

▨ Indicates Potential Release Acres When BMP Management Is Used On Remaining Acres.

Selected Agronomic BMPs:

Factor	Current Practice	Recommended BMP	Environmental Advantages
Variety	Old standard	Best in comparison tests	Better input efficiency
Row-spacing	7-inches	4-inches	Quicker ground cover
Seeding rate	1.5 bu/A	Precision planting at 13 seeds/row ft.	Earlier cover and deeper rooting
Nitrogen (N) management	20 lb/A at seeding, 80 lb/A in late February	20 lb/A at seeding, 40 lb/A in late February; tissue test in April and apply 0 to 70 lb/A based on test	Increases N efficiency; increases growth and crop residue

*Where animal manure or sewage sludge is available, Virginia Tech recommends that the material be analyzed. Calibrate the rate and adjust fertilizer applications to account for this N, incorporate whenever possible, and tissue test for additional N needs as indicated above.

Tramlines	None	Establish tramlines at seeding (no seed in wheel tracks)	Apply N and other inputs with precision

Note: BMPs already used in current practice are: rotations; soil testing and application of recommended nutrients; band application of phosphorus; planting at recommended date; certified seed; and scouting for threshold levels of weeds, diseases and insects.

(see other side)

Results and Summary:

For this above-average farmer in Virginia, adopting more BMPs as shown above increases his wheat yield potential from 50 bu/A to 80 bu/A. Research and demonstrations conducted by scientists at Virginia Tech have developed this technology. Some of the innovative farmers in the state are adopting these BMPs with great success. At the same time, the farmer would have the flexibility to release acreage most environmentally sensitive (see map on the other side) and maintain current total production potential. It would also provide flexibility to increase total production when demand warrants. The implementation of BMPs also increases nutrient efficiency, water use efficiency, and reduces soil erosion potential. The table below summarizes some of these production, environmental and economic advantages of a BMP Program.

Approximate Effects of BMPs on Yield*

Variety	5 to 7 bu/A
Row spacing	5 to 10 bu/A
Seeding rate	3 bu/A
Nitrogen management	8 to 10 bu/A
Tramlines	unknown

*Estimated yield increases are not necessarily additive. Interaction effects with other inputs can change the response. The responses shown are averages from various research trials where these inputs were investigated.

Possible Advantages of BMP Program for Soft Red Winter Wheat Production in Virginia

Factor	Current Practice	Recommended BMPs
Expected yield, bu/A	50	80
Acre release potential from 100 acres to maintain same production	---	37
Total production		
with 100 acres, bushels	5,000	----
with 63 acres, bushels	----	5,040
N rate, lb/A	100	130
N efficiency, bu/lb	.50	.62
N removed in the grain, lb/A	60	90
N remaining (most in residue), lb/A	40	34
Total N applied ,lb	10,000 (100 acres)	8,190 (63 acres)
Total N remaining (most in residue),lb	4,000 (100 acres)	2,142 (63 acres)
Production costs, $/A	160	207
Production costs, $/bu	3.20	2.59
Production costs for field		
100 acres, $	16,000	----
63 acres, $	----	13,041
Profit, $/field 100 acres	2,750	----
63 acres	----	5,859

NOTE: BMP adoption allows this farmer to release land with highest degree of sensitivity to environmental factors (designations A, B, and C in this case, see map on other side) and maintain, or improve, total farm production.

Basis for calculations: Virginia Tech Extension Service ; $3.75 per bushel for the price of soft red winter wheat.

Prepared by agronomists of the Potash & Phosphate Institute (PPI), based on research and extension demonstration information from Virginia Tech.

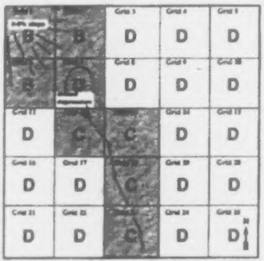
BEST MANAGEMENT PRACTICES (BMPs) for HARD RED SPRING WHEAT in the NORTHERN GREAT PLAINS (MONTANA, NORTH DAKOTA, SOUTH DAKOTA)

Data for this example.

Field size:	100 acres	Average wheat yield for this soil:	30 bu/A
Land description:	Williams loam. A Class 2c productivity soil in Western Montana, N. Dakota, and S. Dakota.	Current wheat yield base for this farmer:	30 bu/A

Selected Soil and Water Conservation BMPs:

Factor	Current Practice	Recommended BMP	Environmental Advantages
Grass waterways	None	Install grass waterways	Less soil loss from surface drain areas (see map)
Tillage	Disk-sweep, clean till	Chemical fallow-sweep, no till between crops	Reduce soil erosion; increase water infiltration and snow catch
Wind erosion	No control, except emergency chisel	Adequate surface residue	Reduce soil loss due to wind
Land environmental impact rating	None	Yes (see map)	



Environmental Impact Rating:

Designation	Rating	Grid Numbers
A	Very Severe	none
B	Severe	1,2,6
C	Moderate	7,12,13,18,23
D	Slight	all others

▨ Indicates Potential Release Acres When BMP Management Is Used On Remaining Acres.

NOTE: The map at right represents a 100-acre field. A soil and water conservation plan should include a rating of the land as to its vulnerability to environmental pollution. This rating can be done on a grid basis (see map) so that those acres most vulnerable to erosion and water pollution can be released (set-aside) first as farmers adopt BMPs. In many situations, the erodible land is the least productive. It can be released from cropping without reducing production on the individual farm.

Selected Agronomic BMPs:

Factor	Current Practice	Recommended BMP	Environmental Advantages
Certified seed	Bin-run seed	Use certified seed	Quicker emergence
Variety	Old standard (tall-type)	Best semidwarf in tests	Quicker ground cover, less lodging
Seeding rate	60 lb/A	Precision planting 30-32 Plants/square foot	Earlier cover to protect soil
Rotation	Wheat-fallow-wheat	Cereal[1]-fallow-wheat-cereal [1](vary depending on water, price,etc.)	Less pest pressure, water efficiency, saline seep control
Weeds	Occasional spring spray	Chemical fallow, scouting for spring spray	Less soil erosion; chemicals used only when needed; conserve moisture
Diseases	Seed treatment	Seed treatment plus scouting for foliar disease thresholds; potassium chloride (KCl) fertilizer.	Chemicals used only when needed
Nitrogen (N) Management[2]			
Soil test	None	Soil nitrate test 7 ppm NO_3-N= 56 lb/A 2 feet	N efficiency
Rate	30 lb/A, no basis	60 lb/A based on yield goal and nitrate test	N efficiency
Timing	All preplant	Split: 50% preplant; 15% at seeding; 35% at tillering	N efficiency

[2] If animal manure is available for use as a nutrient source, it should be analysed for N content, applied prior to seeding and incorporated by tillage. The amount of N available from manure would be taken into account in recommendations for preplant N applications. Soluble salt accumulations from manure should be closely monitored under dryland conditions. The practicality of manure use would also be affected by choice of tillage system.

(see other side)

Factor	Current Practice	Recommended BMP	Environmental Advantages
Phosphorus (P) Management			
Soil test	None	12 ppm Olsen P	
Rate, timing	None	30 lb/A P_2O_5 at seeding	Early ground cover; improved P and N efficiency
Potassium chloride (KCl) Management			
Soil test	None	K=250 ppm (high), Cl=4 ppm (low)	
Rate, timing	None	65 lb/A KCl; apply preplant with N	Reduces chemical input needs; chloride helps disease control

Results and Summary:

This example is for the spring wheat belt in the northern Great Plains. Current practices would produce yields of 30 bu/A. Farmers adopting BMPs as outlined would increase the yield potential to the 45 bu/A range. The yield advantage for BMP production provides flexibility to release acreage most environmentally sensitive (see map on other side) and still maintain current total production potential. It would also provide flexibility to increase total production when demand warrants. The implementation of BMPs also increases nutrient efficiency and water use efficiency, while reducing soil erosion potential. The table below summarizes some of the production, environmental and economic advantages of a BMP Program.

Approximate Effects of BMPs on Yield*

Use of certified seed:	3-8 bu/A increase over bin-run seed.
Better weed control:	3-10 bu/A increase over current practice.
Improved fertilizer mgm't.:	4-15 bu/A increase over current practice.
Improved water storage:	5-12 bu/A increase over current practice.
Disease control:	2-15 bu/A increase over current practice

*Estimated yield increases are not necessarily additive. Interaction effects with other inputs can change the response. The responses shown are averages from various research trials where these inputs were investigated.

Possible Advantages of BMP Program for Hard Red Spring Wheat Production in the Northern Great Plains

Factor		Current Practice	Recommended BMPs
Expected yield, bu/A		30	45
Acre release potential from 100 acres to maintain same production		----	33
Total production:			
	with 100 acres, bushels	3,000	----
	with 67 acres, bushels	----	3,015
N efficiency, bu/lb (soil & fertilizer N) (Higher protein also results with BMP system.)		0.35	0.39
N removed in the grain, lb/A		42	72
N remaining (most in residue), lb/A		44	44
Total N applied, lb		3,000 (100 acres)	4,020 (67 acres)
Total N remaining (most in residue), lb		4,400 (100 acres)	2,948 (67 acres)
Water use efficiency, bu/in		2.9	4.0
Production costs, $/A		120	145
Production costs, $/bu		4.00	3.22
Production costs for field			
	100 acres, $	12,000	----
	67 acres, $	----	9,715
Profit, $/field	100 acres	-600 (loss)	----
	67 acres	----	+2,653

NOTE: BMP adoption allows this farmer to release land with the highest degree of sensitivity to environmental factors (see map on other side) and to maintain, or improve, total farm production.

Basis for calculations: N, $0.20/lb; P_2O_5, $0.22/lb; K_2O, $0.12/lb; Value of wheat: current practice, 13.0% protein, $3.80/bu; BMP practices, 15.0% protein, $4.10/bu.

Prepared by agronomists of the Potash & Phosphate Institute (PPI) based on research and extension demonstration information from Montana State University, North Dakota State University, and South Dakota State University.

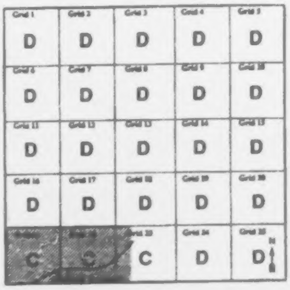
BEST MANAGEMENT PRACTICES (BMPs) for SOYBEAN PRODUCTION IN SOUTHEAST INDIANA

Data for this example.

Field size:	100 acres.	Average soybean yield for this soil:	35 bu/A
Land description:	Claremont silt loam, low organic matter, poorly drained, level to gently rolling.	Current soybean yield for this farmer:	35 bu/A

Selected Soil and Water Conservation BMPs:

Factor	Current Practice	Recommended BMP	Environmental Advantages
Tillage	Moldboard plow	No-till	Less soil erosion; improved water efficiency; maximum benefits occur in combination with solid seeding
Row width	30-inches	Solid seeding	Improved ground cover; less erosion; higher yield potential; maximum benefits occur in combination with no-till
Previous crop	Soybeans	Corn/soybean rotation	Greater plant residue; less soil erosion; higher yield potential



Environmental Impact Rating:

Designation	Rating	Grid Numbers
A	Very Severe	none
B	Severe	none
C	Moderate	21, 22, 23
D	Slight	all others

▨ **Indicates Potential Release Acres When BMP Management Is Used On Remaining Acres.**

Note: The map at right represents a 100-acre field. A soil and water conservation plan should include a rating of the land as to its vulnerability to environmental pollution. This rating can be done on a grid basis (see map) so that those acres most vulnerable to erosion and water pollution can be released (set-aside) first as farmers adopt BMPs. In many sitations, the erodible land is the least productive. It can be released from cropping without reducing total production on the individual farm.

Selected Agronomic BMPs:

Factor	Current Practice	Recommended BMP	Environmental Advantages
Herbicide application timing	Post-emergence herbicides applied too late	Earlier herbicide application	Lower chemical rates required
Planting date	May 15 - June 1	May 10 - May 20	Earlier ground cover; extended time of soil protection
Variety selection	Average for area	Disease and lodging resistant varieties	Reduced yield loss; higher yields
Soil pH	Strongly acid soil, pH 5.0 - 5.5	Slightly acid soil, pH 6.0 - 6.5	Enhanced plant growth; improved efficiency of other nutrients; better nitrogen fixation

(see other side)

Factor	Current Practice	Recommended BMP	Environmental Advantages
Phosphorus (P) Management			
Soil test	Yes - high	Yes - high	
Rate, timing	No P applied	Apply maintenance P to previous corn crop	Soil test maintained; P applied to more responsive crop (corn)
Potassium (K) Management			
Soil test	Yes - Medium	Yes - high	Improved crop tolerance to weather extremes
Rate	None	60-100 lb/A broadcast in spring	Higher yield potential; gradual increase in soil test level
Secondary and Micronutrient Management			
Soil test	No	Yes, but deficiencies not common	

Results and Summary:

This example is taken from southeast Indiana, on a moderately productive soil. In this example, the management is average and can be improved with further adoption of several BMPs as indicated above. Yield potential could be increased 10-25% which gives the farmer flexibility to use more environmentally sensitive acreage for other uses (see map other side). The implementation of BMPs also increases nutrient efficiency and water use efficiency. The table below summarizes some of the advantages for adoption of BMPs.

Approximate Effects of BMPs on Yield*

No-till	3 to 5 bu/A
Solid seeding	5 to 7 bu/A
Corn as preceding crop	3 to 5 bu/A
Earlier planting date	3 to 5 bu/A
Better variety selection	4 to 5 bu/A
Improved soil pH	5 to 7 bu/A
Potassium management	2 to 4 bu/A

*Estimated yield increases are averages from field research where these inputs were investigated. Yield increases are not necessarily additive. Interaction effects with other inputs can change the response.

Possible Advantages of BMP Program for Soybean Production in Southeast Indiana

Factor	Current Practice	Recommended BMP
Expected yield, bu/A	35	45
Acre release potential from 100 acres to maintain same production	--	22
Total production		
with 100 acres, bushels	3,500	--
with 78 acres, bushels	--	3,510
Water use efficiency, bu/inch (22 inches growing season rainfall)	1.6	2.0
Production costs, $/A	240	265
Production costs, $/bu	6.86	5.89
Production costs for field		
100 acres, $	24,000	---
78 acres, $	--	20,670
Profit, $/field		
100 acres	490	---
78 acres	--	3,896

NOTE: BMP adoption allows this farmer to release land with the highest degree of sensitivity to environmental factors (see map on other side) and to maintain, or improve, total farm production.

Basis for Calculations:
Soybean price at $7.00/bu.

Prepared by agronomists of the Potash & Phosphate Institute (PPI) based on research and extension demonstration information from Purdue University and Ohio State University.

Appendix B

Following are reprints of recent articles presenting various views of sustainable agriculture.

"Sustainable Agriculture", by *Myron Johnsrud*

"Sustainability Is Not Enough", by *Vernon W. Ruttan*

"Sustainable Agriculture", by *R.G. Hoeft and E.D. Nafziger*

"Research for a Sustainable Agriculture", by *E.T. York, Jr.*

"A Love Affair with LISA", by *Don Holt*

"Soil Fertility and the Transition from Low-Input to High-Input Agriculture", by *Lin Bao, Jin Ji-yun and S.F. Dowdle*

Sustainable Agriculture

By Myron Johnsrud

The concept of sustainable agriculture has received much attention This article gives the perspective of the USDA-Extension Service.

RAPID CHANGE characterizes today's world. Nowhere is the impact of this change more dramatic than in American agriculture. Prices of major inputs such as energy and money cannot be effectively predicted from one crop year to the next. In the U.S. we are uncertain who our competitors will be. Yesterday's good customer could be tomorrow's fiercest competitor.

Agriculture can be apathetic and let the effects of change take their course. It can react to change out of fear and without adequate preparation. Or it can choose to focus on a new set of basics: world-class quality and service, increased responsiveness to shifting demands, greater flexibility, and continuous short-cycle innovations and improvements aimed at creating new markets for products and services. This latter approach is the route we in Extension have chosen to take.

The rapidly changing environment of agriculture and rural America led the Cooperative Extension System to address critical issues inherent to this change—through a set of Extension national initiatives. To ensure credibility, Extension involved a broad base of people to identify and prioritize the initiatives.

- Competitiveness and Profitability of American Agriculture
- Alternative Agricultural Opportunities
- Water Quality
- Conservation and Management of Natural Resources
- Nutrition, Diet and Health
- Revitalization of Rural America.

Extension is resolving critical issues included in these initiatives. This effort is altering some of Extension's traditional program planning, development, and implementation process. However, it is essential for maintaining relevance in addressing the sustainability of agriculture and rural America. It is compatible with the best of sustainable agriculture and the concept of maximum economic yield (MEY) or most efficient yield.

What is Sustainable Agriculture?

Sustainable agriculture in its best definition provides an opportunity for U.S. agriculture to objectively evaluate best management practices within the context of profitability, environmental soundness, and social acceptability. It is a systems approach to crop production that optimizes the effectiveness of inputs, including producer management. It is characterized by high yield and low unit costs. In reality, sustainable agriculture is a concept without a succinct definition, but can vary from region to region, even farm to farm, and year to year.

Basically, sustainable agriculture involves those farming systems that maintain and enhance the ability of U.S. agriculture to meet human and environmental needs now and in the future. It is also a production system that is profitable and competitive within the global economy. It protects the environment by reducing soil erosion from wind and water. It keeps pollutants out of surface and groundwater by employing fertilizer and pest management practices that result in optimum crop response with minimum "spillage."

Dr. Johnsrud is Administrator of the Extension Service, U.S. Department of Agriculture.

Many of the technological tools now used to maintain competitiveness and profitability of American agriculture are undergoing significant transition, particularly commercial fertilizers and pesticides. Use of these tools is essential to sustain global competitiveness and profitability of American agriculture. Farmers and ranchers will continue to need flexibility in their use, based on such factors as (1) when and if new tools become available that enable U.S. agriculture to maintain its comparative advantage, (2) what policy strategies the U.S. and other nations use to maintain their agricultures' competitiveness, (3) what world weather patterns will be and how they will affect world food supply and demand and (4) whether or not world population will continue to increase as currently forecast.

To maintain present technologies and incorporate new ones will require the cooperation of farmers and ranchers, land grant and other universities, agribusiness and industry, government agencies, and policymakers. Together they can guarantee the use of agricultural technologies in a manner that meets social and environmental as well as economic goals.

Focusing on Tomorrow

Different scenarios are offered to describe agriculture's future. Some believe that worldwide growth in agricultural production has put food shortages behind us and that the capacity to feed the world now and in the future is adequate. Other people think that our apparently excess production capacity in the U.S. results from exploitation of fragile resources, that our productivity level cannot be sustained, and the food shortages or rising real prices in food and fiber will recur. Both of these scenarios have occurred in the past two decades. In the seventies, we could not produce enough food and fiber. In the eighties, we have had difficulty using what we have. In both periods people have said and believed: "never again."

Whatever the scenario American agriculture will face, effective tools and strategies are needed. They must be responsive to an uncertain and fast-changing political, economic, and physical U.S. and world environment.

". . . farming systems that minimize unit costs, produce targeted outputs, recognize the total resource base on farms, and work with the environment."

Systems approaches to problem-solving, such as MEY, provide the most logical response to these needs. We must view agriculture as a system, become "system smart." **This means being involved in creative interdisciplinary teamwork.** Such teamwork, to improve the future of the nation's agricultural economy, must become the norm, not just the desired state.

Interdisciplinary teamwork presents a major challenge to all segments of American agriculture. They must all cooperate in developing farming systems that minimize unit costs, produce targeted outputs, recognize the total resource base on farms, and work with the environment. Long-term competitiveness and profitability cannot be maintained using farm systems that degrade the productivity of our natural resources. We must work to sustain . . . even build . . . our soil and water resources as we capture their abundance through efficient food production.

Summary

Dramatic, dynamic worldwide change is affecting American agriculture. This change has given rise to several critical issues influencing agriculture and rural America. Solution of these issues and opportunities will allow American agriculture to move toward more competitive, profitable, and sustainable production systems. The success of this move will require a winning strategy in which change is seen as an opportunity, not a problem.

All segments of agriculture will need to take more risks, actively cooperate, develop coalitions, overcome constraints, and make the future positive for the U.S. agricultural economy.■

Sustainability Is Not Enough

By Vernon W. Ruttan

Traditional agricultural systems that met the test of sustainability have not been able to respond adequately to modern rates of growth in demand for agricultural commodities. A meaningful definition of sustainability must include the enhancement of agricultural productivity. At present, the concept of sustainability may be more adequate as a guide to research than to farming practice.

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ANY DEFINITION of "sustainability" suitable as a guide to agricultural practice must include **enhancement of productivity** to meet the increased demands created by growing populations and rising incomes. The problems of achieving these goals will be illustrated with some historical examples. The sustainable agricultural movement must define its goals broadly enough to meet the challenge of enhancing productivity and sustainability in both the developed and developing world.

Ambiguity about Technology

The productivity of modern agriculture is the result of a remarkable fusion of science, technology and practice. This fusion did not come easily. The advances in tillage equipment and crop and animal husbandry during the Middle Ages and until well into the 19th century evolved almost entirely from husbandry practice and mechanical insight. The power that the fusion of theoretical and empirical inquiry has given to the advancement of knowledge and technology since the middle of the 19th century has made possible advances in material well-being that could not have been imagined in an earlier age.

These advances have also been interpreted as contributing to the subversion of traditional rural values and institutions and to the degradation of natural environments. They led, in the 1960s and 1970s, to the emergence of a new skepticism about the benefits of advances in science and technology. A view emerged that the potential power created by the fusion of science and technology is dangerous to the modern world and the future of the human race.

This ambiguity about the impact of science and technology on institutions and environments has resulted in a series of efforts to enhance the sensitivity of scientists and science administrators and to reform the decision processes for the allocation of research resources.

These efforts have typically attempted to find rhetorical capsules to serve as a banner under which efforts for reforms might march. Among the more prominent have been "appropriate technology," "integrated pest management," "low-input technology", and more recently, "sustainability."

Reforming Agricultural Research

It is not unusual for such rhetorical capsules to achieve the status of an ideology or a social movement while still in search of a methodology, a technology, or even a definition. If the reform movement is successful in guiding scientific and technical effort in a productive direction, it becomes incorporated into normal scientific or technological practice. If it leads to a dead-end it slips into the underworld of science often to be resurrected when the conditions which generated the concern again emerge toward the top of the social agenda.

> *". . . the commitment to support the development of the research capacity in both developed and developing countries that will be necessary to achieve productive and sustainable agricultural systems has been weakening. And I am also concerned that the sustainability movement is pressing for adoption of agricultural practices under the banner of sustainability before either the science has been done or the technology is available."*

Research on new uses for agricultural products is an example. It was promoted, in the 1930s under the rubric of chemurgy and in the 1950s, under the rubric of utilization research as a solution to the problem of agricultural surpluses. It lost both scientific and political credibility because it promised more than it could deliver. It has emerged again, in the late 1970s and early 1980s, in the guise of enhancing the **value added.**

The **"sustainability"** movement, like other efforts to reform agricultural research, has experienced some difficulty in arriving at a definition that can command consistency among the diverse and sometimes incommensurable reform movements that are marching under its banner. Fortunately we can draw on several historical examples of sustainable agricultural systems.

Sustainable Agricultural Systems

One example was the system of integrated crop-animal husbandry that emerged in Western Europe in the late Middle Ages to replace the medieval two and three field systems. The "new husbandry" system emerged with the introduction and intensive use of new forage and green manure crops. These in turn permitted an increase in the availability and use of animal manures. This permitted the emergence of intensive crop-livestock systems of production through the recycling of plant nutrients in the form of animal manures to maintain and enhance soil fertility.

A second example can be drawn from the agricultural history of East Asian wet rice cultivation. Traditional wet rice cultivation resembled farming in an aquar-

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ium. The rice grew tall and rank; it had a low grain-to-straw ratio. Most of what was produced, straw and grain, was recycled into the flooded fields in the form of human and animal manures. Mineral nutrients and organic matter were carried in and deposited in the fields with the irrigation water. Rice yields rose continuously, though slowly, even under a monoculture system.

A third example is the forest and bush fallow (or shifting cultivation) systems practiced in most areas of the world in pre-modern times and today in many areas of tropical Africa. At low levels of population density these systems were sustainable over long periods of time. As population density increased, short fallow systems emerged. Where the shift to short fallow systems occurred slowly, as in Western Europe and East Asia, systems of farming that permitted sustained growth in agricultural production emerged. Where the transition to short fallow has been forced by rapid population growth the consequence has often been soil degradation and declining productivity.

Sustaining and Enhancing Productivity

This brings me to the title of this paper. The three systems described above, along with other similar systems based on indigenous technology, have provided an inspiration for the emerging field of agroecology. But none of the traditional systems, while sustainable under conditions of slow growth in demand, has the capacity to respond to modern rates of growth in demand generated by some combination of rapid population and/or rapid income growth. Some traditional systems were able to sustain rates of growth in the range of 0.5 to 1.0 percent annually. But modern rates of growth in demand run in the 1.0 to 2.0 percent per year range in the developed countries. They often run 3.0 to 5.0 percent per year in the less developed and newly industrializing countries. Rates of growth in demand in this range lie outside of the historical experience of the presently developed countries[1].

In searching the literature on sustainability I do not find sufficient recognition of the challenge that modern rates of growth in demand imposes on agriculture. **If the concept of sustainability is to serve as a guide to practice it must include the use of technology and practices that both enhance and sustain productivity.**

In the United States the capacity to sustain the necessary increases in agricultural production will largely depend on our capacity for institutional innovation. If we lose our capacity to sustain growth in agricultural production it will be a result of political and economic failure. Failure to reform agricultural commodity programs in a manner that will contribute to both sustaining and enhancing productivity will mean the loss of one of the few industries in the United States that has managed to retain world-class status—that is capable of competing in world markets.

In contrast it is quite clear that the scientific and technical knowledge is not yet available that will enable farmers in most tropical countries to meet the current demand their societies are placing upon them or to sustain the increases that are currently being achieved. Nor has the research capacity that will be necessary to provide the knowledge and the technology yet been established. In these countries achievement of sustainable agricultural surpluses is dependent on advances in scientific knowledge and on technical and institutional innovation.

Implications for Research

I am deeply concerned that the commitment to support the development of the research capacity in both developed and developing countries that will be necessary to achieve productive and sustainable agricultural systems has been weakening. And I am also concerned that the sustainability movement is pressing for adoption of agricultural practices under the banner of sustainability before either the science has been done or the technology is available.

It has been surprisingly difficult to find careful definitions of the term sustainability. This is at least in part because if "sustainability" is to provide a useful rhetoric for reform it must be able to accommodate the several traditions that must march under its banner. These include the organic agriculture tradition, the land stewardship movement, the agroecology perspective and others. In my judgment any attempt to specify the technology and practices that meet the criteria of enhancing and sustaining productivity would be premature.

At present it is useful to define sustainability in a manner that will be useful as a guide to research rather than as an immediate guide to practice.

As a guide to research it seems useful to use a definition that would include (a) the development of technology and practices that maintain and/or enhance the quality of land and water resources, and (b) the improvement in plants and animals and the advances in production practices that will facilitate the substitution of biological technology ~~for~~ chemical technology.

Furthermore, it is desirable to generate the knowledge that will enable us to determine what it is possible to achieve in the direction of the above objectives primarily from a biological perspective. **Maximum yield experiments represent a useful analogy. The objective of a maximum yield experiment or trial is not to provide a guide to farm practice.** Rather it is to find out how a plant population performs under high level input stress.

The research agenda on sustainable agriculture needs to define what is biologically feasible without being excessively limited by present economic constraints.■

Sustainable Agriculture

By R.G. Hoeft and E.D. Nafziger

The definition of "sustainable agriculture" will vary depending on one's viewpoint. This article points out that management systems which achieve the most efficient production and profits, while minimizing adverse effects on the environment, are indeed a form of sustainable agriculture.

THERE IS little evidence to suggest that agriculture as practiced in a variety of ways is not sustainable. We think of sustainable agriculture as a management system that uses inputs — both those available as natural resources on the farm and those purchased externally — in the most efficient manner possible to obtain productivity and profitability from a farming operation, while minimizing adverse effects on the environment.

Several groups have published materials suggesting techniques that should be used to attain the goals of sustainable agriculture. The University of Nebraska has prepared a list of "Components of a Sustainable System," including:

Cultural practices

- Careful variety/hybrid selection for the system
- Crop rotations with legumes
- Winter cover crops
- Intercropping
- Conservation tillage and residue management

Soil fertility programs ("fertilize the crop, not the soil")

- Precision-calibrated soil test and "accurate" fertilizer recommendations
- Band application of fertilizers
- Planting time and sidedress applications of nitrogen (N) for maximum efficiency
- Use of available manures and wastes
- Allowing N credit for legumes and for nitrate in irrigation water

Pest management

- Selecting pest-resistant cultivars
- Use of pest population dynamics, damage thresholds, and decision aids
- Integration of cultural, mechanical, and chemical control methods
- Use of biocontrol agents when available

Water conservation

- Use of the concepts of irrigation scheduling and limited irrigation
- Use of ecofarming and other moisture-harvesting systems in semi-arid areas
- Crop selection based on the efficiency of water use

This is an excellent list of suggestions and is similar to those given in the *Illinois Agronomy Handbook* for many years. For various reasons, some advisers and farmers have not paid adequate attention to some of these items in the past. The following discussion will focus on the validity of those reasons.

Nitrogen

The use of a legume as a winter cover crop is being promoted as a way to produce "free" N for the following crop. Although the production of "free" N is a commendable benefit, it occurs rarely under Illinois conditions or in most of the Midwest. Fall-seeded legumes tend to utilize the residual N from the soil, thus reducing the potential for leaching. But under most Illinois conditions fall-seeded legumes can be shown to fix little additional N for early planted grass crops. Given the severe penalties for delayed planting of corn, delaying planting to allow for N fixation is unacceptable.

Recommendations

Fertilizer is one of the largest single cost items associated with crop production. This factor, combined with the fact that some feel we are "poisoning the soil" with fertilizers, has drawn a lot of attention to fertilizers from the proponents of sustainable agriculture. The Nebraska list suggests that the recommendations for fertilizer use could be more "accurate" and "precise" and that the emphasis should be on fertilizing the crop rather than the soil. Unless followed properly, those recommendations may result in fertilizing the crop by depleting the soil for future generations.

Fertilizer recommendations can be made for the short term, for minimum input, and for maximum profit, or they can be made for a sustainable system. If the amount added is significantly less than the amount removed in harvesting, the soil will eventually be depleted. This situation could hardly be defined as sustainable agriculture.

Soil Tests

Soil tests cannot be calibrated for each particular site (field), so recommendations that are made from a soil test are based on research involving a limited number of soil types. Some recommendations will be above and some below that actually needed for the crop that year. In addition, the vagaries of the weather from year to year make it difficult to be precise in all recommendations. In the long run, the goal of any fertility recommendation based on a soil test should be to obtain a profitable yield while maintaining the fertility status of the soil.

Use Wastes

Animal and other organic wastes have long been applied to the land. Some improvement in utilization of these products might be made, but the impact of such an improvement on U.S. farm input and output figures will be negligible. With current livestock prices and trends in consumer preference, there appears to be little chance that livestock numbers and the waste they produce will increase significantly.

There is ever-increasing interest on the part of the society to recycle and utilize by-products. Some of those products have been shown to be valuable resources for agricultural land under the right circumstances. Because of the cost associated with their disposal, however, manufacturers are usually willing to provide them to agriculture at a reduced cost or, in some cases, at no cost to avoid the disposal fee.

Biological Additives

In addition to utilization of "wastes," some have also suggested the use of biological controls and additives. Commercial agriculture has long used this technique, as evidenced by the continued selection process to achieve disease resistance for many agronomic crops. Similarly, N derived from symbiotic biological fixation by legumes has long been recognized and credited. However, that process is only an economical credit when one grows the legume for the seed or forage

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(Sustainable Agriculture . . . continued)

produced. It has not been economical to grow the legume just for the N, particularly in areas of the country where growing crops occupy the land during a large part of the growing season, thus leaving little time for legume growth.

New Terms?

A new term proposed along with sustainable agriculture is "thought-intensive agriculture." It means "to think carefully about all available strategies in the farm system that can deal with the problem and create production opportunities." Irrespective of the system selected for the farm operation, one cannot argue with that concept. One method is to plant soybeans within a standing crop of wheat, barley, or other small grain. This is hardly a new concept, it has been evaluated in Illinois research for at least 15 years. Even though the results have shown that given the right year it will work well, it has not been widely adopted because of the associated high risk.

The term "regenerative agriculture," is frequently used synonymously with sustainable agriculture. This concept means "the capacity of the natural environment to recover from disturbance." As applied in the present sense, this concept seems to propound a return to the "natural" physical, chemical, and biological conditions of the soil. To deplete present soil nutrient levels to their native state, inactivate current drainage systems, and otherwise work toward returning soil conditions to those in Illinois before farming began, would not only take years, it would also be absurd.

According to Robert Rodale (of Rodale Press), farms that have been worn out and abandoned almost always begin to regenerate within a short period of time. Most of these "worn-out" farms have been intensively cropped without replenishing the nutrients, or the productive topsoil has been allowed to erode. While the topsoil cannot be easily replaced, a good fertility management program will rapidly improve the productivity of such land.

Alternative Crops

In order to be economically sustainable, agriculture must produce a marketable product at a lower cost than the market is willing to pay. This idea has prompted many to suggest that we consider producing alternative crops, new crops that can replace those currently grown.

In order for a new crop to provide much relief to the agricultural economy, it must provide a product that will replace a nonrenewable resource. For example, a crop that could replace a substantial amount of imported petroleum would have a tremendous impact on the agricultural economy. Governmental policies and economic realities will determine the extent to which such crops will be grown in the future.

We accept the concept of "sustainable" agriculture to the extent that it calls for reasonable and conservative use of agricultural inputs. We do not agree, however, with some of the undertones of the movement based upon certain interpretations of this concept.

First, the assumption that American agriculture is incapable of far-ranging change is not true; the changes we have seen in tillage and pest control over the past 20 years would have been considered revolutionary in 1960. As markets have tightened, more attention is given to product quality, alternative uses, and value-added technology. Simply put, the idea that agriculture is uncontrollably headed toward disastrous disruption is at odds with the flexibility that the industry has historically shown. Research will continue to guide the necessary changes.

Risk

A second problem with the present "sustainable" approach is the failure to recognize the increase in risk associated with many of the changes being encouraged. Much of the "proof" to indicate that such changes are beneficial is anecdotal in nature and does nothing to assess risks, beyond the occasional admission that a particular practice failed. Farmers have never been, and never will be, well-served by casually generated "technology." This is not to say that such technology will never work, but rather to emphasize that risk aspects are being ignored in the haste to bring change.

Summary

Finally, we reject the anti-science bias that characterizes much of the present "sustainable agriculture" movement. This bias is very clearly seen in its opposition to many new technologies and in its assertions that public researchers do research only to benefit agricultural input suppliers, rather than farmers. It is difficult to imagine how anyone who has had any contact with research and Extension specialists can continue to hold such views, especially, with the present emphasis on the efficiency of production.

In the end, it is only through use of properly conducted and properly interpreted research that an individual producer, when faced with new constraints, will be able to properly adjust his inputs to maximize net income.■

Maximum Economic Yield (MEY) . . . Sustainable Agriculture at Its Best

MEY is the most profitable yield per acre . . . created by efficient, high volume output at low unit cost. In good times the MEY farmer fully exploits profit opportunities and is sustained at a high income level. In bad times MEY protects him against low prices by the low cost of producing a bushel or a ton of whatever crop he grows.

MEY sustains the agricultural industries that provide services and products to the farmer because his higher profits allow him to reinvest in those vital inputs.

MEY means timely planting, correct populations, balanced fertility, judicious use of crop protection chemicals . . . management of all inputs in a package or systems approach to minimize losses through erosion, runoff and leaching.

MEY controls erosion and sustains groundwater quality by promoting a rapidly growing crop that quickly covers the ground. Greater root proliferation anchors more soil particles and enhances nutrient uptake efficiency. Incorporating more aboveground residue into the soil increases water holding capacity and improves infiltration rate. Root decomposition provides soil aggregate stability.

Yes, MEY protects our priceless soil and water resources, assuring the future of sound, productive agriculture.

In the truest sense, MEY is the best of sustainable agriculture.■

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Research for a Sustainable Agriculture

By E.T. York, Jr.

Sound programs of agricultural research are essential to maintaining the productivity and sustainability of agricultural systems.

"THE NEXT FEW DECADES present a greater challenge to the world food systems than they may ever face again. The effort needed to increase production in pace with unprecedented increase in demand, while retaining the essential ecological integrity of food systems, is colossal, both in its magnitude and complexity. Given the obstacles to be overcome, most of them man-made, it can fail more easily than it can succeed."

This statement by a special panel of the World Commission on Environment and Development presents a sobering but realistic appraisal of the challenge facing global food systems.

This challenge has contributed very directly to the great interest in the sustainability of agricultural systems around the globe. Such interest is well placed.

Progress in Food Production

There has been phenomenal progress in food production since the middle of this century. In fact, from 1950 to 1984, global food production went up 2.6-fold, making possible a 40 percent increase in per capita cereal production — despite rapid population growth during that period.

Today, many are questioning our ability to sustain such increases in food production — or even maintain current levels. Since 1984, per capita production of cereals, worldwide, has declined each year — for a total of 14 percent over the 4-year period. Global grain reserves are projected to be at the lowest level this year since immediately after World War II.

WORLD
FOOD
1984

It is still uncertain whether the drop in agricultural output in the last four years is a short-term aberration due, primarily, to unfavorable weather or whether it is the beginning of a long-term trend which could have some disastrous consequences, particularly to many parts of the developing world already suffering from inadequate levels of nutrition.

The World Bank estimates that over 700 million people, about one-third of the developing world population, do not have enough calories for an active working life. Moreover, approximately one-fourth of the population of both Africa and South Asia do not receive enough calories to prevent stunted growth and serious health risks, according to United Nations agencies.

It is obvious that there must be significant increases in food availability throughout much of the developing world, merely to meet the needs of current population levels. But there is little hope of meeting the growing need of future generations unless significant progress is made in limiting rates of population growth. This is at the heart of current global hunger and malnutrition problems.

Population Growth

Global populations continue to grow at a rate of 1.6 to 1.7 percent, resulting in almost 90 million more consumers of agricultural products annually. More than 90 percent of this growth is occurring in the developing world, many parts of which are already suffering from inadequate food.

90 million
more consumers
each year

Such growth in population not only substantially increases the demand for food year after year, these greater numbers of people contribute to environmental and natural resource degradation problems in ways that threaten the continued productivity of many agricultural areas.

For example, growing needs have forced Third World farmers to clear and cultivate hillsides and other fragile lands. This, along with an intensification of traditional cropping cycles, has resulted in greatly accelerated rates of erosion and loss of soil productivity. The forage needs of livestock in many developing countries now exceeds the carrying capacity of grasslands — by as much as 50 to 100 percent in some areas — leading to severe deterioration and often to desertification. In industrial regions such as North America and Western Europe, increased export demand in the 1970s and crop subsidies more recently have resulted in the cultivation of marginal lands, highly subject to erosion and other forms of degradation. Water resources are being depleted, and air, soil and water are being contaminated by waste products of industry, urban development and some agricultural practices.

These are some of the circumstances that have led many government entities as well as private organizations and groups all over the world to become seriously concerned about the ability of our planet to achieve and maintain sustainable levels of agricultural production.

There have been many definitions or characterizations of agricultural sustainability. However, most emphasize a dynamic concept of accommodating growing needs for agricultural products without degrading the natural resource base on which agriculture depends.

In the U.S., a number of groups are advocating various approaches to achieving sustainable agricultural systems.

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These include those proposing "alternative," "regenerative," or "organic" farming systems. Most of these approaches emphasize a number of practices, including:

- More extensive use of longer cycle crop rotations — in contrast to monoculture or short-term rotations;
- More extensive use of leguminous green manure crops to add nitrogen (N) and organic matter to the soil;
- The use of animal manures to provide both organic matter and nutrients to the soil;
- Less use — or in some cases, no use — of commercial fertilizers, relying on plant and animal residues to supply plant nutrients;
- Less use — or in some cases, no use — of pesticides, relying upon "natural" systems including predators and parasites and upon crop rotations to help keep pests under control.

The Big Question

There is obvious merit in some of these approaches. The value of green manure crops and animal manures have long been recognized. Similarly, crop rotation practices offer many benefits. **The big question is the extent to which such practices can substitute for, or replace, commercial fertilizers and pesticides.**

Leguminous green manure crops may supply N but not other forms of plant nutrients. Even the levels of N supplied by such crops are likely to be inadequate to assure most efficient levels of production and desirable economic returns. Large amounts of animal manures are required to provide needed plant nutrients in many cropping systems, but manures in such quantities are not available to most farmers. While crop rotations may help in the control of some pests, serious pest problems can develop despite the use of sound rotation practices. Many farming systems may not lend themselves to the types of rotations that might offer the greatest advantages from the standpoint of pest control. Perennial fruit crops, for example, pose special problems in this regard.

Inputs

These and other circumstances have led many to question the extent to which certain commercial inputs can be reduced and still maintain a viable and economically sound farming program. Indeed, one of the most controversial issues pertaining to agricultural sustainability relates to the use of inputs — especially pesticides and fertilizers. Some believe that high levels of such inputs threaten sustainability; others suggest that without greater input use, sustainability objectives cannot be achieved. For example, without adequate inputs, many believe it would be impossible to meet the food needs of increasing world populations unless additional land that is less sustainable is brought into cultivation, thereby damaging or destroying natural ecosystems. Organic gardening enthusiasts advocate the use of no commercial chemical inputs — a philosophy sharply in contrast to the type of intensive farming found throughout much of the U.S. and western Europe.

". . . It should be recognized that there is no adequate substitute for the use of commercial fertilizers if agricultural systems, worldwide, are to satisfy the food needs of steadily increasing numbers of people at prices which most can afford to pay. . .

"Where fertilizers are contributing to environmental problems (such as nitrate pollution of groundwater), research should be accelerated to develop means of overcoming these problems. There is little doubt that this can be done, given the great accomplishments of such research in the past."

LISA

The level of input usage has been tied directly to the sustainability issue by the U.S. Department of Agriculture (USDA) through its "Low-Input Sustainable Agriculture" (LISA) program. Many (including this writer) believe it is a serious mistake to link low inputs directly with sustainability. Certainly, the two are not synonymous; one is not a corollary to the other. Moreover, "low inputs" is a very imprecise term. How low? Low in relation to what? What inputs? Systems involving reduced levels of some inputs, such as herbicides, may actually require higher levels of other inputs, such as labor. It is regrettable that the USDA with its long history of leadership in developing scientific approaches to agricultural improvement would adopt such an unscientific approach to a major problem.

More intensive production systems, involving the use of commercial inputs, have been the product of decades of research by both public and private institutions including land grant universities and USDA. Farmers, over the years, have followed the advice and recommendations of these organizations. If problems, relating to such usage, have developed, there is need for **scientifically-based** corrective action. Labels such as "LISA" serve no useful purpose and, indeed, do a disservice to efforts to achieve sustainable agricultural systems.

Research Needs

Research should be organized and carried out to optimize returns from inputs while avoiding undesirable consequences, if any, from such usage. Pesticides and fertilizers have undoubtedly been misused by some in the past. Every effort should be made to avoid such misuse in the future.

Research can undoubtedly lead to a reduction in the need for some pesticides — for example, by developing genetic resistance to many plant diseases and insects. Research can also develop more effective biological approaches to pest control as well as improve systems of integrated pest management. Such research needs to be expanded so that pesticide usage can, indeed, be lowered in a meaningful and cost-effective manner.

Fertilizers

The situation with fertilizers is somewhat different. Chemical nutrients are essential for plant growth. While some of these nutrients can be supplied by soils, nutrient levels in soils are usually inadequate for optimum crop performance. Some nutrients, particularly N, may be provided by plant and animal residues. However, such residues are usually not available to most farmers in amounts needed for optimum crop performance. It should be noted that less than one percent of U.S. food is estimated to be produced organically — that is, without the use of chemical inputs. However, the cost of such food is usually substantially higher because of lower production levels and, at times, greater costs of other inputs such as labor.

It should be recognized that there is no adequate substitute for the use of commercial fertilizers if agricultural systems, worldwide, are to satisfy the food needs of steadily increasing numbers of people at prices which most can afford to pay. Research must continue to determine what levels of fertilizers should be used to meet the demand for agricultural products and give the producer an adequate economic return. Where fertilizers are contributing to environmental problems (such as nitrate pollution of groundwater), research should be accelerated to develop means of overcoming these problems. There is little doubt that this can be done, given the great accomplishments of such research in the past.

Summing Up

Sound programs of agricultural research have provided the technology to enable U.S. agriculture to become the most productive and efficient of any in the world. If some agricultural practices are contributing to environmental or human health problems, our research institutions must address and solve these problems. This is essential to maintaining the productivity and sustainability of agricultural systems so that they can meet the needs of current and future generations — while at the same time the producer is assured of a fair and equitable return for his investment and efforts.■

A Love Affair with LISA

By Don Holt

A movement which has become identified as "LISA" continues to spark interest, concern and dialogue among diverse agricultural and environmental groups. A university administrator offers some thought-provoking observations in this article.

LISA, an acronym for "low-input, sustainable agriculture" is a buzzword in agricultural and environmental circles. In addition to representing a general farming systems concept, the term LISA is used to describe a specific, federally-supported research and education program. The program, administered as a regional competitive grants program, is focused on developing and promoting low-input, sustainable farming systems.

Background

Interest in LISA was stimulated in the mid-1980s by the emergence of some major public concerns about agriculture. During this period the general public was sensitized to water quality, soil conservation, and other environmental issues. Also, the public became concerned about the fate of one of the nation's most treasured institutions, the family farm.

Legislation was introduced in 1983 by Senator Patrick Leahy that would have mandated national demonstrations of low-input systems. After considerable revision and discussion, the current LISA program was funded in 1988.

Supporters and Opponents of LISA

The individuals and groups expressing enthusiasm and soliciting support for LISA state various objectives, such as preserving the family farm, conserving soil and other natural resources, and improving environmental quality. In general, private firms that manufacture and market inputs for agriculture have not been enthusiastic about LISA, for both technical and economic reasons.

When we develop and implement technological changes in agriculture to enhance productivity, we need to consider the potential impact of such changes on our ability to achieve other important objectives. In my opinion the overriding consideration must be profitability. In almost every case it is farmers who must implement LISA systems. If farmers cannot implement these systems as part of profitable farming enterprises, the changes will not be implemented.

The U.S. capacity for production systems research, decision support, and education is inadequate to support major farming systems changes, some of which are mandated by current legislation. Hopefully, LISA systems will never be mandated, but will be carefully studied and developed to the point that they represent economically viable farming systems alternatives.

> "... *In my opinion the overriding consideration must be profitability. In almost every case it is farmers who must implement LISA systems. If farmers cannot implement these systems as part of profitable farming enterprises, the changes will not be implemented.*"

Positive Impacts of LISA

The LISA movement sensitized many people to important environmental, conservation, technical, and social concerns associated with agriculture. It alerted universities and other public agencies to new constituencies, some of which are outside traditional agricultural groups but very concerned about the impact of agricultural practices on the environment and on society.

The LISA issue clearly revealed the need for a major infusion of systems science and systems perspective into agricultural teaching, research, and extension and for an increase in institutional capacity for production and marketing systems research. A systems approach is required to investigate the complex interactions that occur within and among agricultural systems and to predict the effects of these interactions. There is increased awareness of the need for improved field experimentation techniques and a wave of interest in on-farm research.

The LISA movement stimulated a great deal of ingenuity on the part of farmers, agribusiness people, and researchers toward finding more productive, cost-efficient, environmentally safe, and resource-conserving methods of producing crops. The LISA movement created a great opportunity for education, not only of farmers, agribusiness people, and scientists, but also of the general public.

Farm business management, which has received relatively little research attention in the past decade or so, is enjoying an increase in interest and support. The public interest in LISA has generated more financial support for related research and educational efforts.

Negative Aspects of LISA

In general, people associated with agriculture support the concept of sustainability and recognize that sustainable agriculture is not incompatible with but rather is essential to the welfare of both agriculturalists and the general public. The supporters and critics of LISA disagree considerably on what approaches should be taken to achieve LISA goals.

> "... *A systems approach is required to investigate the complex interactions that occur within and among agricultural systems and to predict the effects of these interactions. There is increased awareness of the need for improved field experimentation techniques and a wave of interest in on-farm research.*"

What is meant by low-input?

Critics of LISA are particularly skeptical of the use of the qualifier "low-input." It is not clear whether the term refers to low input per unit of output or low input per unit of land, two very different concepts. Most LISA enthusiasts seem to promote LISA in the latter context. Some proposed LISA approaches actually represent a substitution of one type of input for another, rather than a reduction in level of inputs.

LISA is being interpreted by many to mean that there is some system of agriculture that is productive and competitive, and, at the same time, requires only low inputs per acre or per farm. I believe there is strong evidence that agricultural

(continued on other side)

Dr. Holt is Director, Illinois Agricultural Experiment Station, Champaign-Urbana. This article is adapted from a presentation to the staff and Advisory Council of the Potash & Phosphate Institute (PPI), in April 1989.

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systems involving low variable inputs per unit of fixed assets, e.g., land, cannot sustain themselves in a mature agricultural economy.

LISA and profit

Some sobering conclusions can be drawn from economic relationships among productivity goals, fixed costs, variable costs, and prices of farm products. In a mature, highly competitive agriculture, farmers will have to maximize profits to survive without subsidization. If maximizing profit is the goal, the optimum cost per unit of output will be greater than the minimum cost per unit of output; this is also true if minimizing loss is the goal.

Low-input systems are least appropriate for operations with high fixed costs. A lower price does not result in a proportionately lower cost of the optimum combination of inputs. If low-input systems are those that involve lower levels of inputs than the level leading to minimum cost per unit of output, low input systems cannot be self-sustaining in a mature agricultural industry.

LISA and soil fertility

Some LISA enthusiasts perpetuate misunderstandings about fertility. They do not seem to accept that crops remove essential nutrients, including phosphorus (P) and potassium (K), from soils and that fertilization is necessary to replace those nutrients. Nutrients can be recycled to some extent, by spreading plant and animal wastes back on fields, but not all nutrients removed in crop production are available for recycling.

Extrapolating LISA research findings

Failure to estimate the degree to which alternative systems can be successfully adapted in global agriculture can lead to erroneous conclusions. For example, the proposal that forage-livestock systems should replace grain systems in order to reduce soil erosion and decrease nitrogen (N) inputs fails to take into account the relatively inelastic demand for red meat and other products derived from ruminant animals.

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LISA and productivity

Some LISA enthusiasts downplay the need to maintain high levels of agricultural productivity. They argue that even if the LISA approach resulted in higher prices of farm products, the impact on the consuming public would be minimal. After all, they say, U.S. consumers spend only 15 percent of their income for food and only 25 percent of that expenditure reaches the farmers.

> *". . . When food expenditures are analyzed by income class, however, it is evident that 30 percent of families spend over 50 percent of family income for food and 50 percent of families spend over 30 percent of their income for food. Any policy that results in lower productivity in U.S. agriculture is the equivalent of a particularly regressive tax levied on the consumers of agricultural products."*

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LISA and business strategies

LISA enthusiasts often support the strategies of diversification and vertical integration for small farmers. These strategies are not generally successful when used by small private firms. Any new enterprise added to diversify a farm operation or integrate it vertically must achieve enough economy of scale to be competitive. For example, if a livestock operation is added to a grain farm as a means of diversifying and vertically integrating the farm business, the livestock operation must be large enough and efficient enough to be competitive.

LISA and technological solutions to problems

Some LISA enthusiasts, particularly within some environmental groups, reject all technological solutions to problems. For example, they do not accept the possibility that chemical pesticides can be produced that are harmless to all organisms except the target pests. Likewise, they are unwilling to accept any risk associated with pesticide use, nor to recognize that there are great risks involved in not using fertilizers and pesticides.

LISA and international competition

I don't believe that many LISA enthusiasts fully appreciate the economic consequences of failure to address the issue of agricultural competition. If U.S. agricultural producers are unable to compete for global agricultural markets, there will have to be further downsizing of the agricultural infrastructure, with resulting loss of jobs and economic activity. The U.S. has the natural productivity advantage, potential technological leadership, and well-established infrastructure required to penetrate and capture those markets. As a group, however, farmers cannot compete for international commodity markets without purchased inputs.

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LISA and politics

In my opinion, the political risk associated with supporting LISA is less than that of not supporting it. Many of the LISA support groups represent very large constituencies with great political influence. Our best approach is to join with them in a sincere effort to learn about the potentials of LISA and to help prevent ill-advised policy decisions.

Conclusions

Above all, those of us in the traditional establishment of public and private agricultural research and education must recognize that we are receiving messages from individuals and groups that have legitimate claims on our time and talents. We must not try to "shoot" these messengers. We need to scrutinize carefully each of their concerns, which are also our concerns, and help them find and implement answers.

Our future depends on handling the LISA issue in a scientifically sophisticated, technologically sound, economically realistic, politically sensitive, and socially responsible manner. ■

In China

Soil Fertility and the Transition from Low-Input to High-Input Agriculture

By Lin Bao, Jin Ji-yun and S.F. Dowdle

There are important lessons to be learned from China's experience, particularly for those in developed countries who are advocating reduced inputs or the low-input approach to sustainable agriculture.

CHINA is a vast country where land has been cultivated continuously for centuries. It is mountainous, with only about 10 percent of the land area suitable for cultivation. Yet China's agricultural systems have been providing sufficient food and resources for a large population, and a stable foundation for China's old and rich culture. From a historical perspective, China's agriculture has been enormously successful. In searching for the underlying reasons for this record, one might argue that the basis of success has been the intricate and complex systems for the collection, composting, and recycling of organic materials.

In China, organic fertilizers are composed of farmyard manure and green manure. Farmyard manure is the product of agricultural activities and domestic wastes. The manure mainly includes stalk, straw, municipal wastes, animal and human excrements. Animal excrements account for about 60 percent of the total quantity of nutrients supplied by farmyard manure, while stalk and straw account for about 20 percent. The area sown to green manure has decreased sharply in recent years, falling from a peak of 12 million ha in the 1970s to around 6 million ha today.

However, it is not always fully understood that the maintenance of fertility of lowlands with organic fertilizers was obtained at considerable cost to the nation and the environment. Nutrient losses in the cycle were historically compensated for—organic matter and plant nutrients from the uplands that were not used for agriculture were transferred to the lowlands. Over centuries, this practice has shaped China's landscape—fertile lowlands surrounded by deforested, depleted uplands.

ORGANIC MATERIAL collected in the upland hills has been transferred for centuries to lowland areas for livestock bedding and feed or for fuel. This process has resulted in fertile lowlands and depleted uplands in China.

In the past four decades, however, China's agriculture has undergone a massive transformation. From reliance solely on organic sources of nutrients, China is now the world's third largest consumer of manufactured fertilizers and the world's largest user of manufactured nitrogen (N) fertilizers. The transformation has profound agronomic, social, and economic implications. This change was brought about by the need to increase yields to keep pace with the rapid growth of population which increased from about 600 million in 1953 to 1.05 billion in 1986.

The purpose of this article is to examine some of the developments which led to the transformation, and some of the implications referred to above.

Encouraging farmers to maintain and improve soil fertility through the use of manure is recorded from as early as 3,000 B.C., in records from the Shang dynasty. There are several detailed descriptions of manure preparation, application, variety, quality and effectiveness that have survived more than two thousand years. Concepts such as "the more manure input, the more fertile is the soil", and "soil fertility could be sustained by means of manure incorporation and intensive farming" are deeply ingrained in the collective Chinese consciousness. In fact, these concepts are so much a part of the system they are hindering the development of a proper balanced use of nutrients in today's more modern Chinese agriculture.

It is important to note that the benefits of cycling and utilization of organic nutrient sources have been largely confined to the irrigated highly productive lowlands. Nutrient losses in the cycle were historically replaced by transfer of nutrients from the uplands.

Grain Yields

To gain an appreciation of the transition from traditional to modern agriculture, it is interesting to look at the

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historical trends of wheat and rice yields in China (**Table 1**). Prior to the 1950s, virtually no chemical fertilizers were used in China, as production was sustained for more than two thousand years using organic fertilizer alone. However, yields were relatively low, as was the improvement of soil fertility, especially in dryland farming. The increase in wheat yields from 793 kg/ha to 1,465 kg/ha covered a time span of more than 2,000 years, an average increase of 17 kg **every 50 years.** From 1952 to 1986, wheat yields increased from 735 kg/ha to 3,040 kg/ha, an average increase of 68 kg **every year.** For rice, the increase from 603 kg/ha to 1,560 kg/ha occurred over a time span of 1,200 years, an average increase of 40 kg every 50 years. From 1952 to 1986, rice yields increased from 2,408 kg/ha to 5,338 kg/ha, an average increase of 86 kg **every year.** Between 1950 and 1987, total grain production increased threefold, peaking at a record 407 million tons in 1984.

Table 1. Average yields (kg/ha) of wheat and rice in China from 221 BC-present.

Dynasty	Year	Yield, kg/ha Wheat	Rice
Qin	(221-206BC)	793	—
W. Han	(206BC-AD24)	904	603
Song	(960-1279)	780	1,560
Ming-Qing	(1368-1911)	1,465	2,930
	1952	735	2,408
	1965	1,020	2,940
	1980	1,890	4,133
	1986	3,040	5,338

Adapted from Liu Geng-Lin (1988) and China Agricultural Yearbooks.

This historical perspective demonstrates that since 1952 the increase in grain yields exceeds anything seen before in China's long history. There are many factors responsible for the accelerated growth of the agricultural production, including: improvements in water control; development and dissemination of high yielding crop varieties; improved agricultural education, research, and extension services; and, perhaps most importantly, increased supplies of manufactured fertilizers. The close relationship between grain production and commercial fertilizer consumption is shown in **Figure 1.**

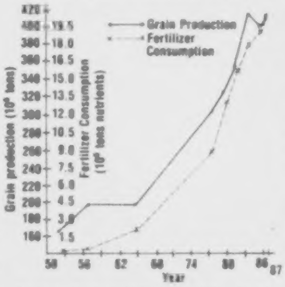
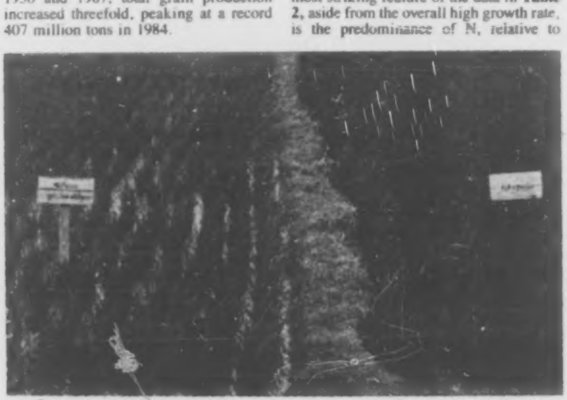


Figure 1. Grain production and fertilizer consumption in China from 1952 to 1987.

Use of Manufactured Fertilizer

The huge growth in use of manufactured fertilizers in China since 1952 is unprecedented (**Table 2**). Perhaps the most striking feature of the data in **Table 2,** aside from the overall high growth rate, is the predominance of N, relative to phosphorus (P) and potassium (K). Why has the use of commercial fertilizer advanced in such an unbalanced manner?



IMPROVED BALANCE in plant nutrient application rates can increase fertilizer efficiency over time. Shown here is rice response to potash in Hunan province. The field on the right received potash, the field at left did not.

Table 2. Consumption of chemical fertilizers in China for selected years, 1952-1987.[1]

Year	Total N, P_2O_5, K_2O	N	P_2O_5	K_2O
	---------	thousand tons	---------	
1952	78	78	—	—
1957	373	320	53	—
1965	1,942	1,331	608	3
1972	4,559	3,228	1,304	27
1980	12,694	10,180	2,386	128
1984	16,133	12,153	3,206	694
1987	17,906	13,268	3,719	919

Data from State Statistical Yearbook and China Agricultural Yearbooks.

[1] Data do not include complex fertilizers. In 1984 and 1987 complex fertilizers accounted for 7.3% and 11.6% of total nutrients applied.

The introduction and acceptance of manufactured fertilizers in China have followed a pattern: a large scale introduction of N fertilizers, followed by P and then K fertilizers. During the long history of China's agriculture and ending only in the early 1950s, nutrient supply depended solely on organic fertilizers, which normally supplied more P and K than N, to sustain the low input and low output agriculture system. As a result, soil organic N was severely depleted. During the 1960s, when high-yielding, fertilizer-responsive varieties of rice, wheat, and corn were released, N was by far the most limiting nutrient. As a result, N use soared far ahead of P and K use. The heavy application of N fertilizers, in turn, stimulated the depletion of soil P and K.

With the increase in use of chemical fertilizers, there has been a decrease in the use of organic fertilizers (**Table 3**).

Table 3. Amount of inorganic and organic fertilizer applied in China.

Year	Total	Source of Nutrient Inorganic	Organic
	N, P_2O_5, K_2O (million tons)	% of total	
1949	4.34	1.4	98.6
1965	9.13	19.3	80.7
1975	16.03	33.6	66.4
1983	28.62	58.0	42.0

Adapted from Chen Li-zhi et al., 1988.

Although data for organic fertilizers in China are variable and inconsistent, the declining trend is incontestable. There are many factors responsible for the decline in the use of organic fertilizers. The rural economy has been particularly buoyant since economic reforms were introduced in 1978. Farmers now have other money earning opportunities besides farming. Thus, there exists a premium on labor in the countryside which never existed before. The time and labor-consuming practices for the collection, preparation, and application of organic fertilizers are out of step with the rapid development of the rural economy.

With increased supplies of chemical fertilizers, and the proliferation of high-yielding, fertilizer-responsive varieties, farmers eagerly buy the limited supplies of chemical fertilizers.

Increases in Production

Since rapid increases in production began in the 1950s, the development of the fertilizer industry and fertilizer practices has not kept pace with the changing needs of China's agriculture. The traditional practices of using balanced, organic fertilizers have been replaced by use of inorganic fertilizers in an unbalanced ratio of nutrients. This change was required in order to supply the increased demand of nutrients by high yielding crops. One effect of such one-sided use of manufactured N fertilizers has been a decline in the efficiency of N fertilizer, and an increase in the effect of P and K fertilizers. Data from the National Network on Chemical Fertilizer Experiments (NNCFE) clearly show these trends (**Table 4**).

Table 4. Changes of chemical fertilizer efficiency with time.

		Yield increase in kg/kg of nutrient	
Nutrient	**Crop**	**in 1958-1963**	**in 1981-1983**
N	Rice	15-20	9.1
	Wheat	10-15	10.0
	Corn	20-30	13.4
P_2O_5	Rice	8-12	4.7
	Wheat	5-10	8.1
	Corn	5-10	9.7
K_2O	Rice	2-4	4.9 (6.6 in South China)
	Wheat	ns[1]	2.1
	Corn	ns	1.6

[1] ns indicates no significant difference was found.

Source: Lin Bao

Prior to the wide availability of manufactured P fertilizers, more P was being removed in the harvests than was being returned to the soil (**Table 5**). Thus, P deficient areas in China have been increasing. A similar situation exists in the case of K. In large areas across south China, soil K levels have been extremely depleted through greater removal of K by intensive cropping than K input rates with organic and inorganic fertilizers. This situation with K depletion is not confined to south China, however. **Table 6** shows data from a detailed study of K input and output on a soil in north China, an area previously thought to be well supplied with K.

Perhaps the best documentation of the decline in soil fertility comes from data from the Chinese Academy of Agricultural Sciences. According to results from China's first nationwide chemical fertilizer trials conducted in 14 provinces during 1936-40, it was estimated that about 80 percent of the agricultural land was deficient in N, about 40 percent was deficient in P, and about 10 percent was deficient in K. More recent results from field trials conducted during 1981-1983 by the NNCFE, established in 1957, revealed that about 74 percent of the cultivated land in China was deficient in P (available P less than 10 ppm), about 40 percent was severely deficient in P (available P less than 5 ppm), and about 23 percent was deficient in K (available K less than 70 ppm). It should be noted that these estimates are based on average results from a large number of field experiments and most probably underestimate the deficient areas when high yielding crops are being grown.

A debate has developed in China, similar to the debate in some developed countries, as to whether organic or inorganic fertilizers are better. The debate is unfortunate in that it draws attention away from the best management practice, which is to use both types of fertilizer whenever possible and practical (i.e. economical). As shown in **Table 6**, when both types of fertilizers are used together under certain conditions, greater benefit can be obtained than when either one of the fertilizers is used alone.

Proponents of strictly organic farming systems tend to overlook two important factors: (a) the adequacy of supply of organic materials, and (b) the high labor costs of collection and application of organic fertilizer sources. Also, little attention is given to the lack of proper soil conservation in the areas supplying organic fertilizer sources for maintenance and improvement of productivity in more suitable agricultural areas.

Whether with organic or inorganic fertilizers, if there is concern as to the effect of cropping on soil fertility, attention must be paid to quantities of nutrients being removed, and quantities of nutrients provided with fertilizers. Organic fertilizers can supply a portion of the P and K required by crops, and therefore slow down P and K depletion processes to some extent. However, with repeated cropping, the amount of P and K supplied in organic fertilizers can hardly meet the requirements of crops.

The unbalanced use of nutrients in China has resulted in severe adverse effects on agricultural production, including increasing incidences of certain diseases, crops of poor quality, declining fertility of soils, and most importantly, stagnation in the increase of agricultural production. Therefore, it will be important to readjust the ratio of N, P, and K fertilizers both in production and in importation so that adequate P and K fertilizers

Table 6. Yield response and K balance in corn-wheat-corn cropping system.

Year	Crop	Treatment[1]	Yield	Increase	K (Applied)	K (Removal)	Balance
			kg/ha	%	kg K/ha	kg K/ha	kg K/ha
1st Crop 1987	Spring Corn	NP	4,546	—	0	32.4	− 32.4
		NPK	7,588	66.9	93.4	69.9	+ 23.5
		NPM	6,235	37.1	21.0	42.7	− 21.7
		NPKM	7,921	74.2	114.4	72.1	+ 42.3
2nd Crop 1987/88	Winter Wheat	NP	2,665	—	0	49.5	− 49.5
		NPK	3,466	30.1	93.4	79.5	+ 13.9
		NPM	2,799	5.0	14.4	54.4	− 40.0
		NPKM	3,750	40.7	107.8	86.7	+ 21.1
3rd Crop 1988	Summer Corn	NP	1,948	—	0	24.0	− 24.0
		NPK	4,471	129.5	93.4	95.1	− 1.7
		NPM	3,154	61.9	0	34.9	− 34.9
		NPKM[2]	5,179	165.8	93.4	89.3	+ 4.1

Data adapted from Jin Ji-yun, 1989.

[1] For NPM, NPKM treatment, cattle compost manure (M) was applied at rate of 13.5 t/ha dry weight.

[2] No manure applied for this crop.

Table 5. Phosphorus balance in China's agriculture prior to widespread use of manufactured P fertilizer.

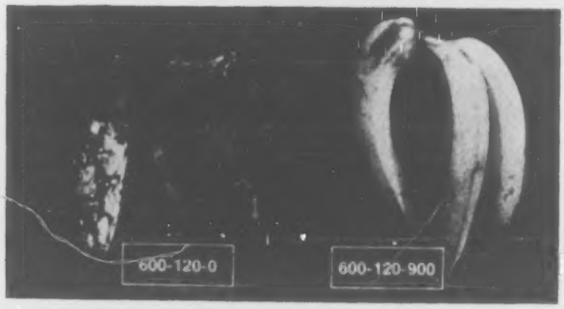
	P input				
Year	**Total**	**Contribution of organic amendments**	**P output in harvest**	**P recycling**	**P Balance**
	(10^3 tons)	(%)	(10^3 tons)	(%)	(10^3 tons)
1949	348	100	607	57	-259
1957	562	96	1038	52	-476
1965	850	72	1043	58	-193

Adapted from Zhu and Xi, 1988.

are available for farmers and balanced use of N, P, and K necessary for sustainable increases in agricultural production can be practiced by China's farmers.

For sustainable agriculture, whether it is in China, the U.S.A. or any other country, soil fertility must be preserved through balanced fertilization. Anything less results in declining soil fertility and theft from the most precious natural resource of future generations—the soil.■

AFTER a continuous cycle of nutrient transfer in organic material, upland areas have become barren while lowlands maintained fertility. Now in China and other Asian countries, crop residues from productive lowlands are often removed for fuel, livestock fodder, and industrial uses. For sustainable, regenerative systems of food and fiber production, crop residues should be returned to the soil.



PROPER USE of fertilizer becomes more important as farmers grow more high value crops and consumers become more quality conscious. In this comparison in Guandong province, potash fertilization greatly enhanced the quality of bananas kept in storage 19 days.

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Statement of Kevin Kessler
Chief, Groundwater Management Section
Wisconsin Department of Natural Resources

Representing the
Wis. Department of Agriculture, Trade and
Consumer Protection
and the
Wisconsin Department of Natural Resources

Before the
Subcommittee on Conservation and Forestry
of the
United States Senate
Committee on Agriculture, Nutrition and Forestry

Concerning Water Quality Protection Issues

October 24, 1989

I am representing the Wisconsin Department of Natural Resources (WDNR) and the Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP) in appearing before you today on the issues of water protection as it relates to agriculture. Wisconsin has been among the most active of the states in addressing this issue during the 1980's, and we hope that our experiences can help the Congress and the federal agencies develop a more effective national program. There are several points which we'd like to bring to your attention on this issue:

The states have and should continue to have the lead role for groundwater protection and nonpoint source pollution control.

Congress has already recognized this lead role of the states in the Clean Water Act as has the U.S. Environmental Protection AGency in its Ground Water Protection Strategy and its Agricultural Chemicals in Ground Water Strategy. For Agricultural chemical problems, Congress has required in Section 319(i) of the Clean Water Act that the states prepare management plans which identify roles of state and federal agencies.

Congress has also provided monies to the states for the past several years under Section 106 of the Clean Water Act for states to prepare state groundwater strategies. These strategies and plans prepared under the Clean Water Act should not be ignored in any federal legislation related to agriculture.

The states already have the legal and the institutional framework in place to address water quality issues.

In Wisconsin as in most other states, groundwater is defined as part of the "waters of the state." We've had laws and a state program in Wisconsin to deal with private wells and drinking water since 1935.

Since 1978 we've had a priority watershed program that has provided state cost sharing for nonpoint source pollution control projects. Our nonpoint source program insures a major role for both our state agriculture agency (WDATCP) and our state water quality agency (WDNR). By working through that program we are able to insure that the state and federal agencies are working in concert on the same priorities and delivering the same message.

In 1984, we passed major comprehensive groundwater legislation. That legislation establishes a comprehensive state groundwater quality standards program. We have "enforcement standards" and "preventive action limits" (a fraction of the enforcement standards) for pesticides as well as many other chemicals. All state agencies must comply with the standards. This comprehensive standards framework has been invaluable during the past five years in addressing our agricultural chemical issues.

The states are implementing important programs dealing with this issue.

During the past year, for example, we conducted a random survey of Grade A dairy farm wells across the state with some surprising results. Of 534 randomly selected wells sampled, 71 contained one or more detectable herbicides. Fifty-five wells had nitrates over our groundwater enforcement standard. In addition, wells with high nitrates were found to have a statistically significant greater chance of having a pesticide detect than wells with low nitrate levels. We are not planning to implement a program for pesticide screening of citizen supplied well water samples for herbicides. This data supplements the data we already had from sampling over 3000 wells during the past several years for one or more pesticides.

Another thing we've done during the past year is coordinate our efforts and prepare a publication entitled "Nutrient and Pesticide Best Management Practices for Wisconsin Farms." We recognized that we can't have our state agencies, our University and the federal agencies delivering different messages and urging different "best management practices" to the same farmers. As a result, our state agencies, our University and the federal agencies agreed that we would develop a single coordinated set of best management practices and a single implementation strategy.

Federal programs need to be better coordinated.

The proposed legislation which we've seen does not assure that the programs of the U.S. Department of Agriculture are in concert with other congressionally mandated programs under Sections 106 and 319(i) of the Clean Water Act and under FIFRA. U.S. EPA has its Agricultural Chemicals in Ground Water Strategy and the states have nonpoint source pollution control management plans approved by U.S. EPA. In the FIFRA program, the EPA strategy calls for states to prepare state and pesticide specific pesticide management plans. There is not an adequate recognition or commitment in the proposed legislation to these other programs. USDA, EPA and the Congress must define roles for the agencies and proceed in coordinated fashion on this issue.

Legislation establishing a broad federal framework on groundwater is needed.

Our experience in Wisconsin has been that having comprehensive groundwater legislation applicable to all state agencies has helped us to deal with the issue of pesticides in groundwater.

Groundwater quality standards are needed, but "regulatory levels of concern" should not be established for just pesticides. There should be a program for establishment of federal groundwater protection standards for all contaminants. From our experience, such standards are needed to assure that the various programs in EPA and USDA have the same objectives. The federal agencies should defer to state standards when a state has more stringent standards than the federal ones.

USDA should recognize the lead role of the states for groundwater protection and nonpoint source pollution control.

The means by which USDA technical and financial assistance is delivered to farmers should be in conformance with the state programs which are documented and approved by the federal government under Section 319(i) of the Clean Water Act, which are part of state groundwater strategies or which are approved under FIFRA. We do not need or want new USDA programs which are duplicative or contrary to state groundwater, pesticide and nonpoint source pollution control programs. We certainly don't need all the problems that would be caused by independent USDA well sampling programs or groundwater protection plans. USDA should not get into the business of doing other agencies' jobs.

Finally, there are major areas where USDA and congressional assistance are needed:

1) Research. Perhaps the most pressing problem which we have is the need for research to give us more answers to what can be done to prevent water quality problems. Research needs are largely national needs, and there should be greatly increased funding to address the priority needs which we have identified. USDA can assist in funding the research, translating the results into recommended management practices, using research results in state and federal regulatory programs, and dissemination of information.

2) Technical Assistance. USDA staff have a wealth of information and expertise which we can utilize. U.S. EPA and the states do not have the technical assistance delivery systems to meet the challenge alone. If the USDA technical field staff are delivering the same message in concert with the states, much can be accomplished.

3) FIFRA Regulatory Programs. EPA and the states need help in developing the portions of the overall program which are regulatory in nature. USDA can help formulate the regulatory solutions and can help at least with the information delivery aspects of the regulatory programs.

I will leave a copy of several publications and documents with the Subcommittee staff and would be happy to answer questions.

Statement by
Gordon Kissel, Executive Director of the
Nebraska Association of Resources Districts
for the
Senate Subcommittee on Conservation and Forestry
October 24, 1989

Mr. Chairman, members of the Senate Subcommittee on Conservation and Forestry, thank you for the invitation to present testimony on the issue of groundwater protection.

Before I address your specific concerns regarding research, data collection, education, technical assistance and regulation, let me take a minute to explain Nebraska's Natural Resources Districts. Nebraska is known as a conservative state and somewhat traditional. However, for those of us who call it home we recognize the strong populist sentiment which exists in Nebraska. We believe that local people can and should govern themselves. We also believe that governments should be efficient and capable. In 1969, the Nebraska Legislature passed a law establishing the Natural Resources Districts. In July, 1972 the Districts became operational. This law consolidated over 150 resource entities.

Nebraska Natural Resources Districts are unique to the country. We are 23 multi-county regional political subdivisions of the state. We have taxing authority which is 4.5 cents on $100 of actual valuation. Each district is governed by an elected board of directors. Each district has professional staff hired to carry out all conservation programs administered by the district. Some districts may have a few employees, while others may have as many as 40-50 employees. The district's budgets range from $300,000 on the low end to over $8,000,000.

The districts have established priority programs within the boundaries based upon the needs. In some districts, flood control is the top priority. In others, it may be soil conservation. While in others, it may be groundwater quantity or quality. All programs are found in most districts, but the priority is set by the locally elected directors. It is clear that in most districts in Nebraska, water quality is becoming a higher priority.

The Natural Resources Districts are seventeen years old. And like many adolescents, we are trying to decide what we want to be when we grow up. We have had moments of great success and other times when we have had to step back and reassess our directions. We are learning and beginning to be more confident in our abilities, our directions and our purpose. We have high expectations of ourselves and the Nebraska Legislature does too. The state legislature continues to give us additional responsibilities as we prove to them we can handle a wide range of natural resources programs.

Local Governments and Federal Programs

It is our belief that local governments must play an important role in the implementation of federal programs. We in Nebraska are arrogant enough to believe that the model we have should be studied by all. There are two specific examples of how the NRDs can and have supported the federal goals. The first example is the role of strong local governments in the implementation of the 1985 Farm Bill. The second example is the program currently being administered by the Central Platte NRD in the Groundwater Management Area. If the 1990 Farm Bill has a focus on water quality (we hope that it will) the efforts of the Central Platte NRD should be viewed as a good model.

The 1985 Farm Bill and the conservation provisions were a critical step in linking farm programs and conservation practices. The requirements of conservation plans went a long way in addressing the critical need of better management of soil. In Nebraska, we have been fortunate to have received a little over $5,000,000 for ACP cost share. In recent years, the state's Soil & Water Conservation Fund has increased to about $4,000,000. The increases began under Governor Kerrey's administration and has continued under current Governor Kay Orr. The local districts have responded to the demand for more cost share money. The districts have combined for an allocation of about $4,000,000 across the state. With the federal, state, and local governments collectively, Nebraska has available about $9.5 million in cost share. This is an example of the New Federalism-but more importantly it allows the federal program to be implemented successfully. Strong, financially capable local districts are a key element in the success of this program.

The second example is in the area of water quality. We believe that the emphasis being placed on water quality in the next farm bill should be applauded. This issue must be addressed and similar linkages to agricultural programs and conservation practices should be made in the 1990 Farm Bill. The federal government should set general goals and objectives and allow local governments to implement programs.

In Nebraska the Central Platte NRD has implemented a Groundwater Management Area and has established restrictions on the use of nitrogen fertilizer. The program is divided into three phases depending on the amount of nitrate found in wells. Each phase has guidelines requiring education, soil and water samples, banning of applications, and the most severe phase bans the application of fertilizer all together. The district employees are busy collecting deep soil probes and well monitoring in an attempt to provide each individual farmer a level of nitrate residue.

Through a series of studies, it has been determined that the residue nitrate (in the soil and the water) can be subtracted from a normal application of nitrogen and produce the same yield. In the process, by using the residue nitrate we are cleaning the soil and the groundwater.

The district has spent over $1.5 million in research studies over the last several years and has found statistically significant relationships. Consequently, when the Groundwater Management Area was established and each farmer was told what needed to be done, 95% of the farmers had complied.

The local relationship between the farmers on the board of directors and the farmer has been a major factor in this program's success.

Data Collection

The collection of data is essential to the success of any water quality program. All of the NRDs in Nebraska have implemented groundwater monitoring programs. Samples are taken at least twice a year and sent to various labs. Depending on what the samples are tested for, the price of analysis ranges from $5 to $850.

It's important that the local governments get some financial assistance for these tests. This is especially true as we begin to do more tests for pesticides.

Areas of Research Specific to Agriculture

- Development of agricultural management practices to keep pesticides and fertilizers in the root zone. (Wisconsin has an excellent set of BMP guideline books.)
- Development of alternative chemicals that would not impair water quality.
- Further research on low input sustainable agriculture.
- Improve techniques for pesticide cleanup.
- New or improved crops that reduce need for chemicals.

Other Areas of Technical Need for Research

- Reliable techniques for unsaturated zone monitoring.
- Subsurface movement and fate of contaminants.
- Additional risk assessment research.
- Impacts of long-term exposure to contaminants.
- New and improved techniques for detecting groundwater contamination.

Other Areas of Assisstance

- Insure the accessibility of groundwater data and analyses. (Coordinate research and information to manage groundwater quality through technology transfer.)

Department of Agriculture
AGRICULTURE BUILDING CAPITOL SQUARE
ATLANTA, GEORGIA 30334

Thomas T. Irvin
Commissioner

Statement of Tommy Irvin
Georgia Commissioner of Agriculture
For the Senate Subcommittee
On Conservation and Forestry Hearing
On Water Protection Issues
October 24, 1989

Mr. Chairman and Others:

Thank you for giving me the opportunity to address an issue of vital importance to us all -- groundwater.

Based on their strong sense of stewardship toward the land, combined with their own reliance on groundwater, farmers have long recognized that it is to their benefit to use agricultural chemicals and fertilizers carefully and responsibly. Yet this knowledge is no longer adequate to reassure the American public that precautions are being followed through. Today's health-conscious public demands proof that water supplies are free from any harmful levels of chemicals -- whether from agricultural or industrial sources.

Georgia is blessed with productive and high quality water supplies, including one of the most prolific limestone aquifers in the world. Not only is this aquifer extensive in scope, we are most fortunate that it lies beneath some our state's most productive farm land. But with the availability of such extensive water resources comes the responsibility of safeguarding these supplies.

Because of the growing concern in the area of water quality, the Environmental Protection Agency (EPA) is currently conducting a National Pesticide Survey. Results from the two year study, designed to indicate the extent of groundwater contamination nationwide, should be released early next year. Community water supplies were included in the study, along with sampling of domestic wells from four Georgia counties -- Candler, Henry, Newton and Walker. Preliminary results from the survey indicate that water sampled in Georgia showed non-detectable levels of the some 150 compounds tested, as well as insignificant levels of nitrates and nitrites.

While the National Pesticide Survey will serve as an excellent tool to identify the extent of groundwater contamination on a national scale, the study is not designed to pinpoint specific problems in each state. For this reason, the Georgia Department of Agriculture has just completed a project, in cooperation with the Georgia Department of Natural Resources' (DNR) Environmental Protection Division, to determine the extent of groundwater contamination in some of our primary agricultural areas. These "worse case" locations were selected not only because the land had been in heavy agricultural use for a number of years, but also because the areas were known to have very porous soil types. In addition, since the survey focused on the presence of aldicarb, a pesticide which has high potential for movement through porous soils to groundwater, fields where crops were grown utilizing this pesticide were purposely chosen. Based on preliminary results of this study, we expect to find very little, if any, contamination of groundwater supplies even in these areas with highly vulnerable soil types, which is good news for Georgia farmers and citizens.

Along with this ongoing project, DNR's Environmental Protection Division has also submitted a proposal to EPA under Provision 106 of the Clean Water Act to sample water for groundwater contamination from pesticides in 60 counties throughout the state. This study will further identify and evaluate the extent of pesticide contamination, if present, in groundwater in the major agricultural areas of Georgia.

We feel that these ongoing state projects closely parallel the national groundwater strategy proposed by EPA. Among other priorities, EPA is currently placing an emphasis on the monitoring of pesticides in groundwater supplies. Monitoring is the one basic element which must be performed in order to plan and effective course of action to protect Georgia's groundwater supplies. If contamination is detected, monitoring groundwater supplies will also help distinguish whether the contamination is a result of pesticide use or from other sources such as manufacturing, storage, transportation or spills. The emphasis on monitoring is, and will continue to be, the most critical part of any successful groundwater strategy and will serve as the basis for any restrictions or enforcement actions which may be necessary.

Although our monitoring efforts to date have not indicated problems in Georgia's groundwater supplies, we recognize that with the diversity of agriculture in our state and the extensive use of pesticides, there always remains a potential for contamination. To help ensure the correct use of pesticides and prevent problems such as groundwater contamination, through the years our department has been a leader in developing and initiating pesticide certification courses to educate those who apply and handle restricted-use pesticides. We are currently working closely with the Georgia Extension Service in developing training materials and training sessions and soon expect to have a program designed to specifically address the conditions and circumstances which promote groundwater contamination along with ways such problems can be mitigated or avoided.

We cannot overemphasize the importance of education in this area. It is much easier to prevent groundwater contamination than to clean up a site once contamination has already taken place. With programs designed to inform and educate those who handle pesticides, hopefully we will not need to rely upon corrective action which, in many cases, is not technically or economically feasible.

Georgia has set the pace in one important respect by very early addressing the need for preventive measures. In 1983, even before the groundwater problem became a national issue, we implemented legislation requiring the installation of protective devices to prevent back siphoning or other inadvertent movement of concentrated pesticides through irrigation equipment. Our program, which goes a step beyond current federal requirements, applies to both pesticides and fertilizers. We feel these requirements represent a positive effort already in place which will help continue to protect our valuable groundwater resources.

Although many states may experience common groundwater problems, because of the wide variety of crops, soil types and cultural techniques in different regions of the United States, many problems are unique to a specific area. Yet, each state is faced with a continuing demand for information, from both individuals and public groups, to better define the scope of groundwater contamination in regard to pesticides.

As I see it, no national program can be sufficiently detailed in scope to provide evaluation of specific state problems -- this must be done on a state by state basis taking advantage of and utilizing the knowledge and skills of those who best know the local area. But to conduct such surveys, funding and technical assistance will be needed. We must continue ongoing efforts to monitor situations on the state level to meet our own needs, as well as to contribute to the development of a national data base and unified national strategy.

With the development of improved and more highly sensitive equipment than is even currently available, in the future we will be able to detect even lower levels of pesticides in groundwater. Even with a strong monitoring program, we still must diligently pursue, develop and apply innovative pest control techniques and find new pesticides which will have minimal impact on the environment. In doing this, we must be sure that our farmers can maintain a level of productivity so that they can continue to produce an abundant, high quality supply of food and fiber for an ever-growing world population.

We must work diligently to protect our groundwater. We have access to the same amount of water we have had since the beginning of time and our challenge is to protect and use this supply wisely. It will not take a miracle to protect groundwater quality. But it will require our willingness to cultivate and support strong national and state programs along with our determination to develop and apply realistic and fact-based solutions.

Farmers' Responses to Policy Alternatives to Reduce Groundwater Contamination from Agricultural Sources

Written Testimony Submitted to the
Subcommittee on Conservation and Forestry
of the Senate Committee on Agriculture,
Nutrition, and Forestry

Hearing on Water Quality Protection

Submitted by

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Introduction

Groundwater supplies drinking water to approximately 53 percent of the nation's population and to 97 percent of the population living in rural areas. It provides about 55 percent of the water used by livestock (Olsenius 1988 and Feliciano 1986). Consequently, the maintenance of groundwater quality is a significant issue of public policy. The quality of the groundwater filling these domestic needs is directly linked to land-use activities (Blatt 1986). Evidence from recent studies indicates that the quality of groundwater is being reduced due to contamination from agricultural as well as other sources (Olsenius 1988 and

Bureau of National Affairs 1988). Major sources of groundwater contamination include: agricultural chemicals (pesticides and fertilizers), manure, feedlots, leachate from septic systems, landfills, mining and oil drilling activities, underground storage tanks, and disposals sites for hazardous wastes.

Agriculturally, the USDA has reported that groundwater contaminated by agricultural fertilizers has been confirmed in 31 states and contamination from pesticides has been found in 37 states (Olsenius 1988). In December of 1988, the EPA reported residues attributed to normal agricultural use of 46 pesticides had been found in the groundwater of 26 states (Bureau of National Affairs 1988). These problems, in addition to those associated with nonagricultural activities, are a prime reason for hearings such as yours and the broad range of public reactions and legislative initiatives to limit groundwater contamination.

The agriculturally related initiatives directly impinge on farm operators by invariably affecting the availability and cost of chemical inputs or imposing limits on the amount and timing of chemcial applications. These regulatory activities are frequently tied to programs monitoring well water quality. While many of these initiatives have been publically debated and some have been signed into law, the data reporting on farmers responses to various policy initiatives is limited. In this testimony, we summarize findings from two different studies that address farmers' responses to various initiatives to control groundwater contamination from agricultural sources.

The Studies

The first study was conducted in five separate counties, each in a different state and each representing different kinds of farming operations (Esseks et al. 1989). Data were collected in spring and early summer of 1988. A total of 568 farmers were interviewed using face-to-face interviews. All five areas had had residues from fertilizers or pesticides detected in their groundwater. Briefly, the study sites include: dairying and grain farming in Pennsylvania's Lancaster County; peanut production and cattle in northwestern Florida's Jackson County; grain and livestock production in northwestern Iowa's Cherokee County; potatoe and draiy production in Portage County Wisconsin; and fruit and nut production in Stanislaus County in California's Central Valley.

These sites have considerable diversity in their hydrogeological conditions: groundwater contamination is a problem in both Lancaster and Jackson counties because of their karstic geology; pollution is a problem in Portage County Wisconsin due to the presence of sandy soils and glacial moraines permitting the rapid leaching of chemicals into shallow aquifers; in Cherokee County, Iowa silty soils permitting rapid percolation of water and chemicals to shallow aquifers has resulted in contamination of the groundwater; and aquifers under Stanislaus County are vulnerable to contamination due to deposits of unconsolidated materials that do not protect the groundwater from surface activities.

Funding was not adequate to conduct scientific surveys of all agricultural areas in the nation experiencing agriculturally derived contamination of their groundwater, however our strategy was to select diverse sites to determine if farmers would have similar or divergent attitudes. Similarities did emerge; since they are derived from very different contexts, we suspect these views are shared in other parts of the country.

The second study is an analysis of the implementation of Title XII of the 1985 Food Security Act (Esseks and Kraft 1988). While this study involves a series of surveys with landowners eligible for the Conservation Reserve Program, in 1989, the survey instrument was expanded to included questions on groundwater contamination and policy options. Five sites (watersheds or groups of townships) are involved in this study: Grant County, Wisconsin; Pike County, Missouri; Richland County, Illinois; Washington County, Indiana; and Wayne County, Iowa. With the exception of the Indiana site, groundwater pollution from agricultural activities is a potentail problem rather than an actual one. As of this writing, 504 farmers had been interviewed across the five sites using telephone interviewing.

Results and Discussion

In both studies, farmers were asked about groundwater contamination and various policy alternatives. The reactions of the farmers in the first study where groundwater contamination was a problem were supported by the results in the second study were contamination is not a problem.

Table 1 indicates in four of the five survey sites there was majority or near-majority support for a regulatory policy of banning the use of specific fertilizers and chemicals within 100 feet of wells in areas were groundwater contamination is a high risk. Similarily, high pluralities or majorities of farmers supported restrictions placed on the timing of fertilizer applications over broad areas such as watersheds when these were high risk areas. Similar support existed for restrictions placed on the amount and timing of pesticide applications.

These results indicate that farmers located in areas experiencing groundwater contamination support regulations on the timing and application of agricultural chemicals. Additional analysis indicated that with the exception of Lancaster County, the farmers supporting some form of regualtion were not "hobby" farmers.

Table 2 reports data on the interviewees' perceptions about groundwater problems. There is broad support for programs of well-water testing: across the five sites 80 to 95 percent of the farmers supported regular testing. Furthermore, 64 to 88 percent supported the need to reduce the infiltration of agricultural chemicals into the groundwater. Of the farmers interviewed 45 to 64 percent were concerned about their own domestic water supplies being contaminated by agricultural sources. These farmers who are living with problems of groundwater contamination appear to recognize the problem and to be generally supportative of efforts to reduce the serverity of the problem. In these areas there appears to be support for exploring policy alternatives aimed at controlling the extent and continuation of groundwater contamination.

While the data in tables 1 and 2 are from farmers in areas where groundwater contamination is a recognized problem, the data in table 3 are from areas where such problems do not exist. The exception is the Washington County site. Across these five sites, from 44 to 74 percent of the respondents believe that within ten years that agriculturally derived groundwater contamination will be a problem in their counties. Furthermore, they believe that within the next ten years their own domestic water will be adversely affect by agricultural chemicals: from 35 to 51 percent believe this will happen.

Given the policy activity surrounding groundwater problems, we asked these farmers to respond to a policy initiative in which local governments would be given the power to regulate applications of agricultural chemicals. From 60 to 72 percent of the respondents supported such an initiative.

We believe that our findings support a policy approach through which state or local governments would be able to regulate the amount and timing of chemical applications by farmers in areas vulnerable to groundwater contamination. While were we not able to explore policy alternatives in great depth, our results indicate that farmers both in and out of areas experiencing groundwater problems are aware of the potential for problems and the need to explore alternatives to control contamination. That is, rather than imposing state-wide bans or limitations, there is support for regulatory authorities limiting specific farming practices detrimental to groundwater quality in areas suspectable to groundwater contamination. While relevant to groundwater generally, such a regulatory framework would be useful for aquifer recharge areas suspectable to contamination.

Summary

Data from two different surveys indicate that farmers in very diverse areas share a concern for groundwater contamination from agricultural sources. This concern is realized in support for policies that reduce the threat of contamination in high risk areas. The respondents supported flexible regulations based on high risk areas rather than broadly based state-wide bans.

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Table 1: Farmers' opinions of proposed regulatory policies for preventing ground water pollution from agricultural activities in areas of high risk of contamination, by survey site

Proposed policies	Survey Site: County and State				
In areas of high risk, state government may:	Lancaster County (PA)	Jackson County (FL)	Portage County (WI)	Cherokee County (IA)	Stanislaus County (CA)
	% selecting each response option				
Ban specified fertilizers and chemicals near wells (i.e., with 100 yrds)					
Oppose strongly	30	9	23	14	29
Oppose moderately	31	20	21	19	24
Favor moderately	24	46	39	40	32
Favor strongly	15	23	17	27	15
No response	0	2	0	0	0
Favor mod./strong	39	69	56	67	47
Restrict amount & timing of application of specified fertilizers within an entire area (e.g., watershed)					
Oppose strongly	33	19	25	15	23
Oppose moderately	27	34	23	29	25
Favor moderately	34	38	38	38	39
Favor strongly	6	8	13	18	13
No response	0	1	1	0	0
Favor mod./strong	40	46	51	56	52
Restrict amount & timing of application of specified herbidices & insecticides in an entire area					
Oppose strongly	29	15	16	14	23
Oppose moderately	32	31	27	24	24
Favor moderately	29	42	33	44	42
Favor strongly	10	11	23	18	11
No response	0	1	1	0	0
Favor mod./strong	39	53	56	62	53
Number of respondents	(105)	(130)	(129)	(125)	(79)

Table 2: Farmers' perceptions of ground water contamination problems: their responses to statements about problems, by survey site

	Survey Site: County and State				
Statements	Lancaster County (PA)	Jackson County (FL)	Portage County (WI)	Cherokee County (IA)	Stanislaus County (CA)
	% selecting each response option				
There are areas in my county that need to have well water tested regularly to see if fertilizers, manure, or agr. chemicals are present.					
Strongly disagree	0	3	0	1	3
Disagree	11	6	4	7	16
Agree	78	79	80	82	62
Strongly agree	11	11	15	9	18
No response	0	1	1	1	1
Total agree	89	90	95	91	80
In my county there is a need to reduce the infiltration of fertilizers, manure, or agr. chemicals into GW.					
Strongly disagree	0	2	1	0	3
Disagree	14	22	8	29	27
Agree	75	69	76	62	57
Strongly agree	10	5	12	5	7
No response	1	2	3	4	6
Total Agree	85	74	88	67	64
I am worried about fertilizers, manure, or agr. chemicals being in the water used in my home.					
Strongly disagree	2	5	5	10	5
Disagree	51	29	43	38	49
Agree	37	59	42	44	35
Strongly agree	10	5	9	8	10
No response	0	2	1	0	1
Total agree	47	64	51	52	45
Number of respondents	(105)	(130)	(129)	(125)	(79)

Table 3: 1989 Survey: Farmland owners' perceptions of groundwater problems and their response to a regulatory policy option, by survey area

	Survey areas				
	Grant County (WI)	Pike County (MO)	Richland County (IL)	Wayne County (IA)	Washington County (IN)
	----------% selecting response option----------				
Are there areas of the county where the contamination of groundwater from agricultural fertilizer or pesticides is likely to be a problem within 10 years or less?					
Yes	74	52	44	58	61
No	17	29	38	31	27
Don't know	9	19	18	11	12
Are you worried that within the next ten years or less the water used in your house may be polluted from agricultural fertilizers or pesticide residue?					
Yes	41	38	42	35	51
No	58	60	57	63	48
Don't know	1	2	1	2	1
Let's say that it was proven that certain parcels of farmland had soils or sinkholes that cause agricultural chemicals to infiltrate down to the groundwater and pollute that water if the applications of chemicals are excessive. Should local governments be given the power to regulate chemical applications on such farm parcels so that applications are not excessive?					
Yes	72	62	60	65	65
No	22	25	32	29	28
Don't know	6	13	8	6	7
Number of respondents	(117)	(87)	(77)	(133)	(90)

STATEMENT OF THE AMERICAN FARM BUREAU FEDERATION TO THE SENATE AGRICULTURE, NUTRITION AND FORESTRY SUBCOMMITTEE ON CONSERVATION AND FORESTRY REGARDING WATER QUALITY

October 25, 1989

On behalf of the Farm Bureau, I am pleased to address the very important topic of water quality and groundwater protection. The American Farm Bureau Federation is the nation's largest general farm organization, with over 3.5 million member families in 49 states and Puerto Rico. Our members produce nearly every kind of crop or commodity grown and harvested commercially in the United States.

Mr. Chairman, members of the Subcommittee, I commend you for holding this hearing as we prepare to develop a new Farm Bill. I believe that there is a need for research, education and technical assistance to agricultural producers in the area of water quality. From Farm Bureau's perspective, the Farm Bill is an appropriate vehicle and we look forward to working with you toward this goal.

The protection of our water resources, from both a quality and quantity standpoint, is essential to the future of agriculture. As has been noted many times in recent years, over 90 percent of our rural population relies on groundwater as a source of drinking water. No one has more at stake over the protection of water resources than farmers and ranchers. We live on the land we work, and our own wells or streams are often the first indication of possible problems. This concern has been demonstrated by agriculture, long before water quality became a "public" issue. Farm Bureau has had a water quality program and has conducted training and educational workshops for our members for more than a dozen years. These programs have focused on both groundwater and surface water protection, and have promoted practices designed to prevent contamination and soil erosion. I offer this only as evidence that contrary to public perception, farmers are vitally concerned about the issue and have been active for some time.

At this point in time, agricultural chemicals are important and necessary tools for farmers and ranchers to produce the quality and quantity of food and fiber and at a price which consumers have come to expect. In many cases, farmers and ranchers have no alternatives to the products they must currently use.

As we have all learned in recent years, water quality is a very complex issue. There is a tremendous need for research into the causes of groundwater contamination, how to prevent it, and what effects trace amounts of contaminants will have on health and the environment. Indeed, the more we learn, the more we realize the need to learn more. The lessons from Iowa's groundwater problems underscore the need to proceed carefully. Contrary to early thinking, the evidence from Iowa is now showing that the general application of pesticides and fertilizers may not be the primary cause of contamination. Rather than this being a non-point source problem, it now appears that much of the contamination can be traced to point sources, such as a sink-hole, cracked well casings, drainage wells, applicator mixing and loading sites, and commercial facilities. Such information is extremely important in determining what the appropriate response should be. It also suggests that we should proceed cautiously or risk spending time and money trying to respond to the wrong concerns. Furthermore, it underscores the fact that this is ultimately a problem where the solutions are local in nature and generally site and soil specific.

We believe that public policy should recognize the need for states and local governments to have primary responsibility for addressing this issue. However there is an essential role for the federal government to play if we are to have a consistent and coordinated response. Specifically, we believe that the federal government must take the lead in developing standards, establishing broad policy guidelines, undertaking research and providing technological and financial assistance.

From agriculture's standpoint, we believe that the Department of Agriculture is particularly well suited to address those aspects dealing with research technical assistance and cost sharing. The Soil Conservation Service (SCS), the Agricultural Stabilization and Conservation Service (ASCS), the Agricultural Research Service (ARS), the Cooperative State Research Service (CSRS) and the Extension Service all have extensive technical, scientific, data collection and outreach capability that should be utilized. Specifically, we believe that this Committee should look for ways in which the 1990 Farm Bill could address these needs. We are ready and willing to assist you in this effort.

Let me now turn to the issue of research and information needs that I believe are desired and would benefit the farm and ranch community. Sound information is absolutely essential to good decision making at the farm level. We believe the Committee should explore the opportunities for cost and technical assistance to farmers and ranchers. Many of the Best Management Practices will cost money to implement, such as new application and tillage equipment, installing concrete pads around mixing and loading sites, digging new wells, establishing filter strips, etc. Short-term economic considerations should not serve as barriers to long-term environmental quality. The Committee should also consider the establishment of a cost-sharing program for well testing. We believe that a well testing program should be voluntary and confidential, and should not be linked to denial of farm programs benefits. Such a linkage presupposes an unwillingness on the part of agriculture that doesn't exist and would contribute to an atmosphere of suspicion and finger pointing. If action is necessary, the basis should be that any water quality problem found is the result of longstanding, generally accepted farming practices and lawful use, not misuse, therefore the focus should be on incentives rather than penalties.

With regard to specific research needs, we suggest the following areas for consideration:

Predictive Modeling: How can we better understand what happens to chemicals after application, and what can be done to predict their fate prior to application? How can this information be used routinely on the farm?

Plant Nutrition: Additional research is needed to determine the optimum level of nutrients necessary for crop production. More efficient nutrient management will reduce both input costs and the potential for contamination.

Environmental Fate: We need to learn more about the movement and behavior of farm chemicals after they are applied. What can be done to encourage breakdown? What role does soil and water management play?

Chronic Effects: What are the long-term health effects of consuming drinking water with trace amounts of pesticides? Additional research should be done to determine whether the human immune system and nervous system are affected.

Integrated Pest Management (IPM): What needs to be done to increase utilization of IPM on a broad scale? How do EPA's regulatory decisions affect the adoption of IPM technologies? What are the research and data needs necessary to foster widespread use of IPM programs? What is the most effective means of communicating this information to farmers? The widespread adoption of IPM is a priority for Farm Bureau.

Biotechnology: We need to strengthen research on alternatives to chemical pest controls as a way to increase options available to farmers and ranchers. The development of microbial agents for weeds, diseases, insects, the introduction of resistance into crop plants and even the degradation of chemical waste offers great promise to agriculture. We need to examine the regulatory impediments that may inhibit research and marketing of those products.

Crop Rotation: Examination of crop rotation practices to find the optimum soil/crop rotation should help reduce the need for herbicide, insecticide and fungicide controls by keeping pest populations in check.

Integrated Farm Management Practices: This is what we believe the concept of lower input use means at the farm level. An integrated farm management systems approach incorporates tillage, nutrient, chemical and pest management within the context of conservation practices, soils and crop production plans. The systems approach may help reduce energy costs, input costs, soil erosion and contaminant leaching. It offers agriculture some exciting long-term possibilities from the perspective of improving net farm income and environmental protection.

Undoubtedly, there are many more areas where research would be appropriate. We would be happy to work with the Committee to identify those areas.

As I indicated above, the Farm Bureau has had a great deal of interest in the issue of groundwater protection for many years. In the absence of federal and state regulation, there has been a concerted "private sector" effort aimed at educating and informing farmers and ranchers about ways to protect groundwater.

Farm Bureau's commitment to assist farmers in protecting their groundwater extends throughout the organization. Hundreds of county and State Farm Bureau workshops and training programs have been conducted with a focus on conservation practices, awareness, prevention and well testing. Examples of some activities include the following:

* AFBF initiated its own Conservation Tillage Action Plan in 1983. It is designed to encourage state and county Farm Bureaus to take a more active role in promoting conservation tillage. County Farm Bureaus in South Carolina, Tennessee and Indiana contributed funds or time to set up demonstration and equipment rental programs where none existed.

* Over 1,000 copies of AFBF's booklet, "Farm Partners, Have You Hugged Your Soil Lately?" have been distributed. Also, over 40 sets of a slide show illustrating the program have been distributed. The material takes a systems approach to soil compaction, erosion and protective soil cover. The workshop includes actual field experience and stresses cooperation with local extension and soil and water experts.

* The Georgia Farm Bureau, is planning to incorporate a water quality program at this year's annual convention.

* North Carolina, South Carolina and Virginia Farm Bureaus have initiated and helped pass state laws allowing tax credits for farmers who purchase certain conservation tillage equipment.

* In addition, the Ohio Farm Bureau, Soil and Water Conservation Service, Extension and EPA are working jointly to promote a conservation tillage program with Ohio farmers. The group is interested in developing economic incentives to encourage farmers to adopt conservation tillage practices.

* Oregon Farm Bureau helped initiate a voluntary disposal program for empty pesticide containers in conjunction with the Oregon Agricultural Chemicals Association. The pilot program in 1984 involved one site and collected 8,000 containers. In 1986, the program involved 15 sites and collected 20,000 cans.

* Massachusetts Farm Bureau has been instrumental in getting several departments of the state government to work together on, and the state legislature to fund, a demonstration program for composting manure. This stabilizes nutrients and reduces odor.

* New York, Connecticut and Massachusetts Farm Bureaus have been active in seeking state support of IPM studies.

* In 1986, the American Farm Bureau Federation convened a study committee to examine the various policy issues associated with groundwater legislation pending in Congress. The focus of the committee was to assess the impact on agriculture of the various options and to make recommendations to the Farm Bureau Board of Directors. The recommendations were subsequently discussed and approved by our voting delegates.

* In February, 1986, the American Farm Bureau Federation conducted an educational water testing program at its annual Program Kickoff Meeting. Samples were received and analyzed from 44 states.

* The Farm Bureau has also prepared a Self-Help Checklist designed to help farmers and ranchers analyze their own water supply and farming operations. This publication instills an awareness of good operating practices and also serves as a record keeping system for annual tests of pH levels, nitrates, bacteria and dissolved solids.

In addition to the Checklist, Farm Bureau has joined with the National Agricultural Chemicals Association, the U.S. Extension Service and the National Agricultural Aviation Association in the preparation of another publication entitled, "Protecting Our Groundwater--A Grower's Guide." This publication was designed to assist the growers by promoting safe pesticide handling practices. Literally tens of thousands of these booklets have been distributed to farmers and ranchers across the country in the last year.

* In 1988, 83 out of 92 county Farm Bureaus in Indiana offered nitrate screening of water well samples at their county fairs. Indiana Farm Bureau also participated with the Purdue Agronomy Department in a screening program at the Agronomy Farm Field Day.

* Pennsylvania Farmers Association (Farm Bureau) tested nitrates for about 1,000 farmers at the statewide Ag Progress Days.

* North Dakota Farm Bureau has worked with their state Health Department to test well water for nitrates at NDFB's statewide annual meeting.

* Michigan Farm Bureau, in cooperation with Michigan State University and the Michigan Department of Public Health, tested over 1,500 drinking water samples for nitrates for its members.

* Kansas, Massachusetts, Maryland, Minnesota, New Mexico and New Hampshire Farm Bureaus have conducted workshops utilizing Farm Bureau's Groundwater and Environmental Pollution Self-Help Checklist at their annual meetings.

* Ohio Farm Bureau has distributed over 100,000 Self-Help Checklists to its members and has been part of a cooperative nitrate testing program with Heidelberg College and other groups. As of June, 1989, 76 counties participated and more than 16,000 wells were tested. Ninety-seven percent (97 percent) of the samples were less than 10 ppm. Sixty-eight percent (68 percent) showed no contamination at all. It is interesting to note that the northwestern quarter of Ohio has lower levels of nitrate contamination than most other areas of Ohio. This is noteworthy because this same section of the state has the most intensive agricultural land use, in terms of row crop agriculture. Nitrate contamination is rather common in the forested areas of southeastern Ohio, as well as in the agricultural and forested areas of southwestern Ohio.

While modeling techniques like DRASTIC are helpful in making first cut estimates as to where problems might exist, the data from Ohio show some counties that are in much better shape than DRASTIC would indicate and others that may have more problems than DRASTIC would suggest. Data like this indicate that a single wellhead protection law would be inappropriate in trying to address all situations.

Recognizing this, the American Farm Bureau Federation's board of directors recently authorized development of a water testing program similar to Ohio's that would be offered nationwide to state Farm Bureaus for them to use.

In conclusion, farmers and ranchers have made a strong commitment to protecting their water resources from agricultural chemicals, absent a specific federal policy. That commitment and concern will continue to grow because of the unique dilemma that the issue poses for farmers and ranchers.

We appreciate your considering our views and look forward to assisting you and the Committee in any way possible.

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